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This study tested four physical-political map layouts designed for pupils in grades 4-6. The project studied the effect of modifying traditional classroom and textbook maps on performance in map reading. The four map designs tested were the traditional map; a map using a unified legend, more elaborate symbols, and fewer type sizes and styles; a location map using two colors and simpler symbols; and a map using nonstandard and highly contrasting colors, extended grid lines, compass rose, and other innovations. The pupil performance tests indicated that for this class of students, a modification of traditional maps to include the use of a unified legend, a compass rose, prominent lines of latitude and longitude, and no more than three type sizes or styles improves map reading ability. The use of different colors had indeterminate results. The study indicated that the superior map format would be proportionately beneficial to the middle grade student regardless of variables such as socioeconomic standing, I.Q., sex, and learning aptitude. [In Appendix B, Color Photographs of Maps, legibility of print is marginal and maps will not appear in color]. (LN)

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FINAL REPORT

Project No. 7-D-071
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TESTING THE EFFECTIVENESS OF CLASSROOM MAPS

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George Peabody College for Teachers

Nashville, Tennessee 37203

May 1969

The research reported herein was performed pursuant to a contract with the Office of Education, U.S. Department of Health, Education, and Welfare. Contractors undertaking such projects under Government sponsorship are encouraged to express freely their professional judgment in the conduct of the project. Points of view or opinions stated do not, therefore, necessarily represent official Office of Education position or policy.

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SUMMARY

This study involved comparison of cartographic options in map design. Criterion was level of performance on questions requiring use of each map. All four maps designed for the study presented data on the Iberian Penninsula and adjacent land-water areas: One map was similar to the physical-political design commonly provided for pupils in Grade 4-6. A second map had a unified legend, more elaborate system of symbols, and reduced number of type sizes and styles. The third map was simplified further with a yellow background for land areas and white for water, it being hypothesized that elimination of multiple color combinations would result in higher scores on locational questions. The fourth map carried nonstandard highly contrasting colors, extended grid lines, unified legend, compass rose, and other innovations.

Ninety-six children (32 each from Grades 4, 5, and 6) were shown the four maps individually in sessions separated by 5-7 days. Each session required 30-50 minutes and involved 63-70 test items. Test form and order of presentation of maps were counterbalanced, to distribute evenly any practice effects or test form differences.

Statistically significant results (.05 level or better) indicated clearly that modification of contemporary map designs is in order. Children were able to read the two nonstandard physical-political maps better than the one patterned after traditional designs. Sub-test analyses indicated that a map intended for middle grade pupils should carry a complete and unified legend, compass rose, prominent lines of latitude and longitude, and probably no more than three type sizes or styles. Choice of color apparently remains highly discretionary with the cartographer, since elimination of most color (Map 3) did not tend to improve performance on other map reading tasks. However, use of highly contrasting colors to show elevations resulted in somewhat better performance on questions directly related to use of the color key, but this may be offset by decreased performance on locational questions. Sex differences were minimal, with the males performing significantly higher on two of the twelve comparisons. On other status variables (SES, I.Q., grade level, scores on standardized map reading tests), pupils with higher rankings tended to perform better than lower ranking contemporaries, no matter which map was used. Since there were no two-way interactions, however, it appears that a superior map format will be proportionally beneficial for all middle grade children, regardless of sex, I.Q., SES, or general ability to read maps.

BACKGROUND

Maps showing land elevations, water depths, and other physical features of the earth--in addition to numerous political features including location and population of cities, national boundaries, and names of countries--are an integral part of upper elementary and secondary school social studies programs. Despite their general availability and use, however, there is insufficient evidence that classroom and textbook maps do the job for which they are intended. Indeed, there is some evidence that both children and adults miss the significance of many facts and relationships presented on traditional maps. To a large extent, this failure may be the result of a tendency for map design to be governed more by cartographic custom and armchair logic than by research on the extent to which children can utilize the information contained in the maps.

Related Research

Examination of the research summary and extensive bibliography by Sabaroff (1957) and the annotated list of social studies doctoral dissertations compiled by McPhie (NCSS, 1964) reveals a dearth of experimental work comparing map designs. However, the importance of good map design was underscored by Benjamin Fine's (New York Times, 1951) survey which revealed that students in American colleges were distressingly deficient in geographic knowledge. Many of the 4,752 students included in the study were unable to define such terms as delta, altitude, latitude, or isthmus. Other students could not locate or identify important nations and major rivers on outline maps. It seems evident from this and other similar reports that even maps intended for adults must be exceedingly well designed and must avoid unwarranted assumptions about the user's knowledge of land features or of the area being shown.

Two early studies by Howe and Thorp, reported in the Thirty-Second Yearbook of the National Society for the Study of Education (1933) indicated that upper elementary school children performed poorly in map reading ability tests, despite the rather heavy emphasis given to place-name and locational geography at that time. Neither study considered the possibility that part of the fault might lie in the design of maps, rather than in children, teachers, or instructional approaches. A more recent study by Rushdoony (Elementary School Journal, 1963) concluded that map reading instruction should be moved down to primary grade levels. Such a trend could intensify any existing difficulties caused by poor map design.

The most directly relevant investigations on map design have been reported by Bartz (1965). Since the Bartz studies were designed for testing and improvement of a publishing concern's products, they have been copyrighted and their distribution carefully controlled. The bulk of the studies are not now and may never become generally available to the profession. It is known, however, that Bartz found many commonly accepted procedures for showing boundaries, elevations, city populations, and location to be neither understood nor utilized by girls and boys in Grades 4-8. As a consequence, she made a number of suggestions to Field Enterprises for changes in design of World Book Atlas and other maps published by the firm. While the Bartz suggestions were based on research and while they seem quite logical, they must be regarded as hypotheses. Their validity had not been tested by using maps based on them in comparison with traditional and other innovative map forms.

Objectives of the Study

The investigations reported here had three main objectives:

1. To measure the ability of fourth, fifth, and sixth grade pupils to extract information and perceive relationships on a "traditional" physical-political map.

2. To determine if certain alternate map designs would be more effective than the traditional map in communicating these same physical-political data.

3. To discover if children of different age, grade level, intellectual ability, map reading achievement, sex, or socio-economic status had differential needs in map design.

Specific Hypotheses

Eleven major hypotheses were established. Each related to an important factor commonly shown on classroom maps.

H-1 (Vertical Scale). Highly contrasting colors with no obvious relationship to vegetation or other surface color will more effectively convey differences in vertical scale than will traditional schemes using blues for water depths and yellow-green-brown for land areas.

H-2 (Horizontal Scale). A unified legend with associated and prominent scale in miles will facilitate measurement and estimation of distance.

H-3 (Direction). Extending grid lines into the margin of the map and more clearly marking them will aid in determination of direction between points.

H-4 (Direction). Placing a compass rose prominently on a map will result in higher scores on direction-related test items than either a traditional or extended grid line system.

H-5 (Location System). Extending grid lines into the margin of a map and more clearly marking them will aid in use of latitude and longitude for locational purposes.

H-6 (Physical Features). Use of a highly contrasting color scheme for vertical scale will not convey differences in elevation or depth more effectively (H-1) but will aid in location, identification, and description of physical features of the area.

H-7 (Political Features). Use of a set of varied and distinctive symbols to mark population and function of cities will be more effective than use of a series of similar but differentiated circles to show population and the underlining of capital cities to mark their function.

H-8 (Overall Design). Use of prominent "tags" with color omitted under lettering will result in more rapid and accurate identification of important physical and political features of the map, i.e., names of countries, large cities, oceans, mountain ranges, and the like than will the usual lettering over background system.

H-9 (Overall Design). Use of a single background color for all land areas--and white for water areas--will result in higher scores in location of places than will use of various color tints.

H-10 (Overall Design). Reduction of the number of type sizes on a map from seven to three will aid in identification of physical and political features.

H-11 (General Utility). All factors considered, there will be significant differences in children's ability to extract information from the three physical political maps; that is, children will do better on one of the maps than the other two--or the three may be hierarchial in general effectiveness as communication media.

Description of Procedures

To compare alternative designs, four maps based on the Iberian Peninsula were developed. A major non-standard feature common to all four maps was substitution of North American names from middle grade elementary school textbooks for the French, Spanish, and Portuguese names ordinarily shown on maps of this area. The substitution was made both to ease vocabulary problems which might interfere with accurate testing and to help eliminate bias which could result from prior knowledge of the region. Rationale for each of the four maps is provided in detail in Appendix A; a color photograph of each map appears in Appendix B. The four maps differed in the following respects:

Map 1: Traditional Color Scheme and Layout. Map 1 followed traditional cartographic custom in design, lettering, and use of color. It and all of the other maps were approximately 10 inches by 14 inches in size, slightly larger than a textbook map and roughly the same as a desk outline map or atlas map.

Map 2: Modified Traditional. Map 2 represented an attempt to use the same scale, color scheme, and layout of the first map, but had grid lines extended into the margins of the map to make them more prominent and used a system of symbols to more clearly identify cities of different populations and function. In addition, the map was simplified through use of only three letter sizes and type styles, rather than the seven variations used in Map 1.

Map 3: Location Map. Map 3 was "incomplete" in the sense that it did not attempt to show all of the things carried in Maps 1, 2, and 4. Basically, it resembled Map 1 in many respects, except that it carried a compass rose as in Map 4. The big difference between Map 3 and the other three was in use of color; all land areas were a light yellow and all water areas left white. This design tested the hypothesis that colors used to show relief or other features would tend to make location of cities and places more difficult.

Map 4: Non-Traditional, with Highly Contrasting Colors. Map 4 used the same scale and in many ways the same layout as Maps 1 and 2; however, the color scheme showing elevations was non-standard and to some extent "non-realistic." Map 4 carried a compass rose, unified and rather complete legend, and had "tags" to label nations, major cities, and the most important physical features of the area.

Instruments

Four parallel forms of a map reading test were developed and validated in the pilot phase of the project. Total scores on the tests furnished an overall comparison among the three complete physical-political maps (Maps 1, 2, and 4). Scores on appropriate subtests provided a measure of each map's relative effectiveness in conveying physical and political information; other subtests permitted comparisons in overall design, vertical scale, horizontal scale, direction, and location or grid system. Since Map 3 did not carry elevation and water depth data, comparisons involving it were based on scores covering all areas except vertical scale.

Preliminary work in development of map reading tests was undertaken during the 1967 spring semester, before submission of a proposal to the Office of Education. Fifth and sixth grade children in the Peabody Demonstration school were shown a prototype of Map 1 and asked sample questions of the type later used in the pilot studies and main investigations. While the data obtained were somewhat informal, results were encouraging and ability to develop three forms of a map reading test seemed assured. Bloom's Taxonomy of Educational Objectives: Cognitive Domain (1956) was used as a guideline in preparation of items for inclusion in the four test forms. Use of the Taxonomy assisted greatly in achieving comparability in the four parallel forms and in providing an adequate assessment of all levels of understanding. Copies of all four tests, in final form, are included in Appendix C.

Socio-economic status of children was estimated from local school data. This was simplified by use of two discrete school populations: one serving mainly youngsters from upper middle class homes and the other serving children from upper-lower and lower-middle class families.

An estimate of intellectual ability was obtained through administration of the nonverbal form of the Lorge-Thorndike Intelligence Tests for Grades 4-6 (Houghton-Mifflin, 1962). This test has been described by reviewers in the Fifth and Sixth Mental Measurements Yearbooks (Buros, 1959, 1965) as one of the best group instruments available. The nonverbal form of the test was chosen to give an adequate measure of ability among children with reading problems or from deprived homes.

General map reading ability was measured through use of the Map Reading Subtest of the Work-Study Skills section of the Iowa Tests of Basic Skills (Houghton-Mifflin, 1956). This is one of the few specific tests of map reading ability; reviews indicate that it is well designed and reliable.

Testing Procedures

Each child included in the study was exposed to each of the four maps previously described and to all four test forms. Since every subject was exposed to every map and test variation, he in effect served as his own control, minimizing the kind of error which occurs when one group of subjects is matched against another. The exceptions here, of course, occurred when comparisons were made between SES, grade, I.Q., and sex groups.

Each form of the test had 63-71 items divided among seven subtests. Administration of each test form was approximately 30-50 minutes. To avoid fatigue or discouragement each test session was broken into two segments, with a short relaxation pause for a small piece of candy or cup of soft drink. Testing sessions with each of the four maps were separated by a period of 5-7 days to minimize learning carryover from one map to the next and to avoid excessive interference with normal schedules. Two additional sessions were scheduled on a group basis--one for administration of the Lorge-Thorndike Nonverbal Test of Intelligence and the other for the Iowa map reading subtests.

Research Design and Sample

A total of 96 subjects from the Metropolitan Nashville Davidson County Public School System were tested in the main studies. These children were enrolled in two schools, on serving upper-lower/lower-middle SES families and the other upper-middle class pupils. At each of three grade levels, four through six, there were 32 subjects--16 from each school. All testing with the maps took place in the Mobile Research Laboratory of the Institute on School Learning and Individual Differences. (A drawing of the physical layout of this laboratory is provided in Appendix D.)

The order of presentation of maps and test forms was counterbalanced within each grade and SES level as illustrated in Figure 1. One randomly selected subject was assigned to each of the sixteen different sequences reflected in this design. For example, one low SES, fourth grade child was tested first on the traditional map using Form A, second on the modified traditional map using Form B, third on the two color map using Form C, and finally on the non-traditional map using Form D. Each sequence of map and test form reflected in the above design was administered to one subject for each of six grade-by-SES level combinations.

Practice effects and test form differences which might have

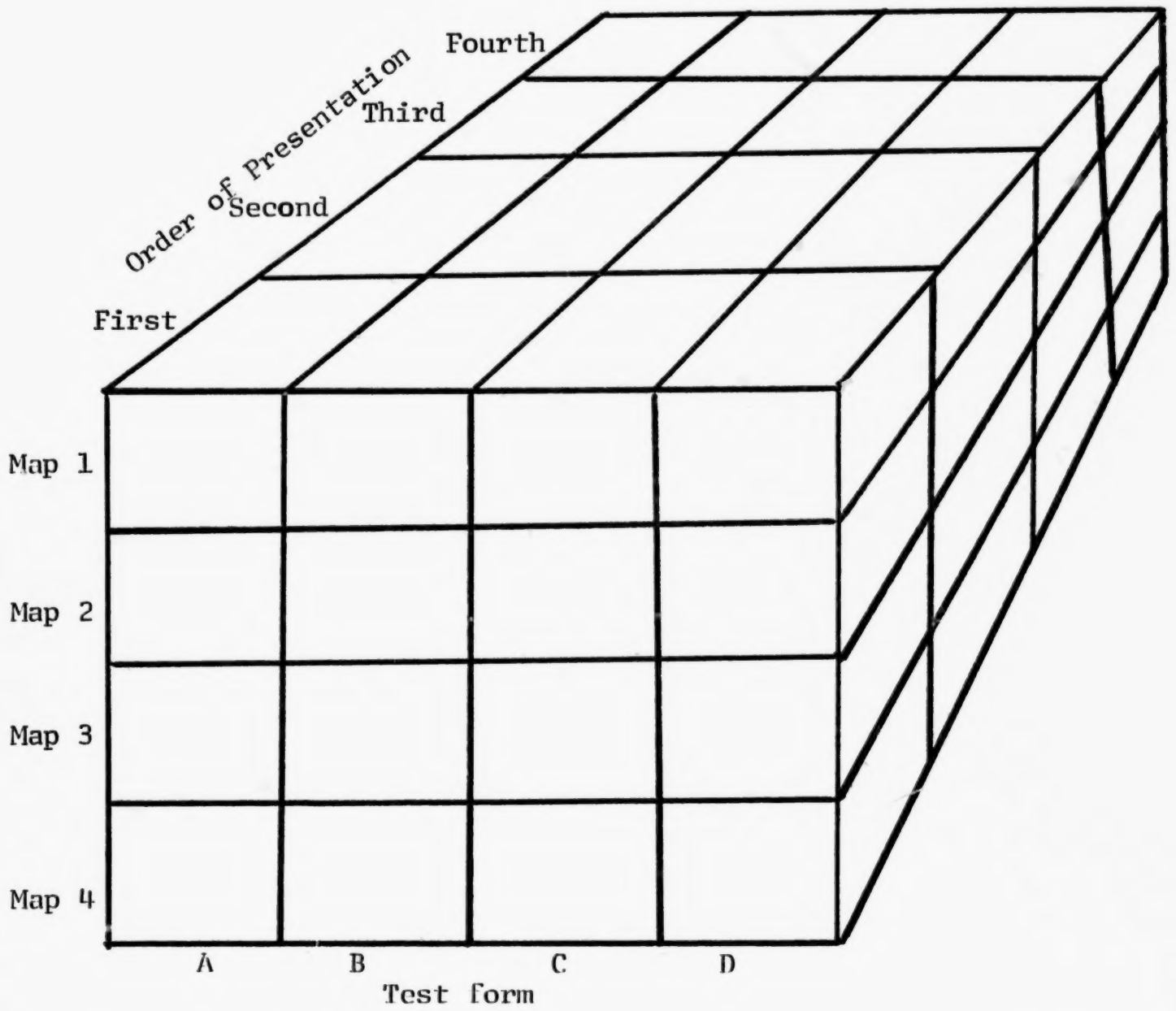

Figure 1. Design for Map and Test Administration within a Grade and Socio-Economic Level.

existed in spite of a 5-7 day interval between test sessions and care in the development of parallel test forms were eliminated from the comparison of the mean scores for different map treatments by the procedure outlined above. Any residual effects from these two variables were, therefore, treated as error variance on a repeated measurements design--the Type III described by Lindquist (1953) and the Case I described by Winer (1962). Figure 2 shows the Type III design applied to the main study data in the proposed investigation.

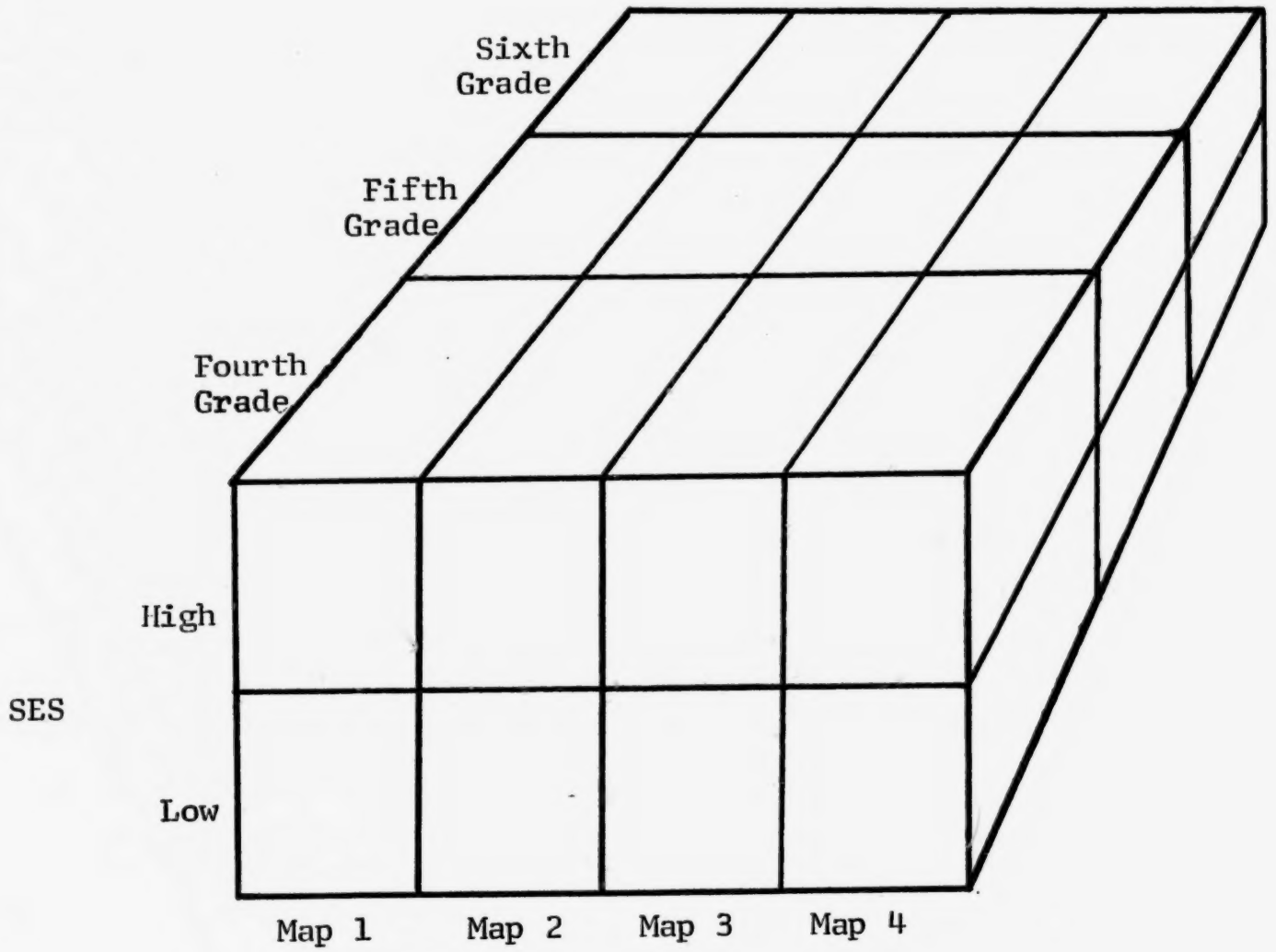

Figure 2. Design for Main Statistical Analyses, Using SES as the Status Variable.

Time Schedule

The investigations were divided into three main phases. The pilot phase began on February 15, 1968 and was completed by March 15. Conclusion of the pilot studies was followed by a short period in which maps and tests were assessed and revised; the Mobile Laboratory then was moved to the first public school site and all other preparations were concluded for initiation of the main studies phase of the project. The main studies began on April 1, 1968 and ended May 30--with a brief interruption while the Mobile Laboratory was moved to the second public school center. The third phase of the studies involved data analyses and preparation of this final report.

FINDINGS AND ANALYSES

Eleven major hypotheses were tested in the course of the investigation. Each related to an important factor commonly shown on classroom atlas, textbook, and wall maps. The hypotheses are repeated in the section that follows and significant differences ($P < .05$) are noted. Differences between status variable subgroups--grade level, sex, SES, I.Q., performance on the Iowa map skills subtest (referred to as the Iowa)--are not reported in detail here. Instead, they are merely noted on the summary tables in Appendix E, since it was not a major purpose of the study to establish such findings as the superiority of high I.Q. subjects over low or that sixth graders tend to perform better than fourth. The status variables did serve a major control function, however, in removing sources of variance and thereby permitting a more precise estimate of the differences between the four maps. Map scores and grade level were included as the within subjects and one dimension of the between subjects measures, respectively, for each analysis. Sex, SES, I.Q., and performance on the Iowa made up the third (between subjects) dimension. As might be anticipated, the relative impact of status measures varied from subtest to subtest, so that differences between map forms were significant in some analyses within a hypothesis and not in others. Where differences were found, either the means were inspected to see which was higher ($N=2$) or the Newman-Keuls procedure (Winer, 1962, pp. 80-85) for multiple t test comparisons without violation of specified levels of significance ($N > 2$) was used to discover the nature of differences.

Analysis of variance summary tables for each of the hypotheses are provided in Appendix E; a summary and discussion of results appears in the concluding section of the report.

Comparisons of the Four Maps

H-1: Highly contrasting colors with no obvious relationship to vegetation or other surface color will more effectively convey differences in vertical scale than will traditional schemes using blues for water depths and yellow-green-brown for land areas. (Maps 1 and 2 vs. Map 4)

Significant differences on questions involving the use of color in determining vertical scale were not found when sex, SES, or performance on the Iowa were used as controls. However, when differences in I.Q. within grade level were controlled, children

scored higher on Map 4 than they did on combined Maps 1 and 2 (.05 level).

H-2: A unified legend with associated and prominent scale in miles will facilitate measurement and estimation of distance. (Maps 1 and 3 vs. Maps 2 and 4)

The two maps with unified legends produced significantly higher scores than did the two maps where legend and scale in miles data were separated. This difference appeared in all data analyses. When scores were controlled on sex, SES, and I.Q. the differences were significant at the .01 level. When performance on the Iowa was used as a control the difference was significant at the .05 level.

H-3: Extending grid lines into the margin of the map and more clearly marking them will aid in determination of direction between points. (Map 1 vs. Map 2)

Results tended to be negative. When I.Q. was controlled, there was no significant difference between the two maps. When performance on the Iowa was used as a control, there was a triple interaction between map scores, grade level, and performance on the Iowa. In the two analyses involving sex and SES as control variables, however, there were significant differences (.05 level) favoring the conventional map design over the design with grid lines extended.

H-4: Placing a compass rose prominently on a map will result in higher scores on direction-related test items than either a traditional or extended grid line system. (Maps 1 and 2 vs. Maps 3 and 4)

On analyses where I.Q. or performance on the Iowa were used as controls, a triple interaction resulted. However, on the two analyses where sex and SES of the child were used as control variables, children scored higher on direction-related maps with a compass rose than they did on the two maps without a compass rose (.01 level of significance).

H-5: Extending grid lines into the margin of a map and more clearly marking them will aid in use of latitude and longitude for locational purposes. (Maps 1 and 3 vs. Maps 2 and 4)

Significant differences favoring the maps with extended and more clearly marked grid lines were found in all four analyses. When sex, SES, and the Iowa controls were applied, the differences were significant at the .01 level. When I.Q. was used as a control variable, the difference was significant at the .05 level.

H-6: Use of a highly contrasting color scheme for vertical scale will not convey differences in elevation or depth more effectively (H-1) but will aid in location, identification, and description of physical features of the area. (Maps 1 and 2 vs. Map 4)

No significant differences were found.

H-7: Use of a set of varied and distinctive symbols to mark population and function of cities will be more effective than use of a series of similar but differentiated circles to show population and the underlining of capital cities to mark their function. (Map 1 vs. Map 2)

In three of the analyses--those using sex, SES, and I.Q. as control variables--there were no significant differences. When prior performance on the Iowa was used as a control, however, children made significantly higher scores (.05) level on the map with differentiated circles and underlined capital cities.

H-8: Use of prominent "tags" with color omitted under lettering will result in more rapid and accurate identification of important physical and political features of the map, i.e., names of countries, large cities, oceans, mountain ranges, and the like, than will the usual lettering-over-background system. (Map 4 vs. Maps 1, 2, and 3)

None of the data analyses on this hypothesis approached significance. The lowest probability found was .55.

H-9: Use of a single background color for all land areas--and white for water areas--will result in higher scores in location of places than will use of various color tints. (Map 3 vs. Maps 1, 2, and 4)

With the exception of the analysis employing levels of performance on the Iowa map skills subtest, there were virtually no differences in mean scores between Maps 1, 2 and 4 on the one hand and Map 3 on the other. Even with the Iowa as a control, the F-ratio with 1/48 degrees of freedom was only 2.77 ($P > .09$).

H-10: Reduction of the number of type sizes on a map from seven to three will aid in identification of physical and political features. Maps 2 and 4 vs. Maps 1 and 3)

Scores tended generally to be higher on maps with fewer type sizes. When SES and performance on the Iowa were used as control variables, the difference was significant at the .01 level. When sex was used as a control variable, the difference was significant at the .05 level. When I.Q. of the subjects was used as a control, the differences between scores on the maps approached but were not great enough to be significant at the .05 level.

H-11: All factors considered, there will be significant differences in children's ability to extract information from the three physical-political maps, that is, they will do better on one of the maps than the other two--or the three may be hierarchal in general effectiveness as communication media. (Maps 1, 2 and 4)

Total scores on the two experimental maps were significantly higher than on the traditional map in three of the four analyses. When sex, SES, and Iowa test performance were used as controls, scores on the modified traditional map exceeded those of the traditional map at the .01 level. The non-traditional map with highly contrasting colors yielded scores exceeding those from the traditional map at the .05 level. There were no significant differences between Maps 2 and 4. A triple interaction prevented a similar overall comparison among the three maps with I.Q. as a control variable.

Another means of making overall comparisons among the maps was to eliminate items related to elevation and water depths, thus permitting inclusion of the two-color map which did not carry vertical scale data. While results were not so clear-cut as in comparison of the three physical-political maps, they were parallel, with Maps 2 and 4 superior in most analyses; with sex or SES controls, Map 2 produced higher scores than either Map 1 or Map 3 (.01 level). When performance on the Iowa test was used as a control variable, Map 2 scores exceeded those of Map 3 at the .05 level. Scores on Map 4 also tended to be higher than on Maps 1 and 3, but not so dramatically. With sex as a control, there were no significant differences between Map 4 and the other three; with SES or the Iowa test as controls, children scored higher (.05 level) on Map 4 than on Map 3--with no significant difference between Map 4 and Maps 1 and 2. When I.Q. was used as the control variable, a triple interaction prevented overall comparisons among the four maps.

DISCUSSION

The major premise of the study, that modifications of a traditional map would be reflected in improved performance in map reading, clearly was supported by the results. Overall, two of the three experimental maps tended to be superior to the traditional map. Looking at various components of difference between these two and the traditional map, it is possible to single out the need for a prominent, rather complete legend or key as one major factor in good map design. A second factor to include, whenever the map is to be used for identification of direction, is a compass rose. In this regard, mere extension and labeling of lines of latitude and longitude, which also can be used for directional identification, are almost useless. However, when locations are to be read from the map or points on the map identified in terms of latitude and longitude, emphasizing the lines is a significant aid to the child. The contention that children can read a map more accurately when only three or four type sizes are used--with good size differentiation between them--was supported by this study.

But the issue of color is still somewhat ambigious. Using highly contrasting, non-realistic colors seems to provide a slight edge on the usual green-blue-brown color schemes. The margin is slight, however, and, overall, the most radical map in this study did not fare so well in total scores as did the modification of a traditional design. The idea of limiting maps to two background colors to reduce distraction when locating places, direction, and similar tasks were not supported at all by the results; evidently middle grade children are able to screen out coloration distractions in solution of other map problems. The choice of symbol systems for children's maps is not so completely obvious, although indications are that the more traditional approach of using varied circles to show population and underlining the names of capital cities is superior to adoption of a more elaborate and differentiated set of special symbols. Similarly, the innovation of eliminating colors behind labels of prominent cities, political divisions, and land features to make "tags" is ineffective.

The findings related to status variables also are worthy of note. First, the results show a steady increase in performance on map reading tasks from grade four through grade six; pupils in higher grades demonstrated increased competence in map interpretation, probably as a function of social studies instruction. Ability to read maps, as with so many other academic skills, is affected by such status factors as SES, I.Q., and performance on the map reading section of the Iowa Tests of Basic Skills. Sex of the child may have some effect on map interpretation, with the boys as

a group doing slightly better. It must be noted, however, that of twelve comparisons over sex, the boys scored significantly higher on only two.

The most important of the findings related to status variables was the total absence of two-way interactions. This indicates that a map design feature which is superior for one subgroup is proportionately superior for other subgroups of the same category. Data obtained in this study would not support contentions that fourth graders, girls, lower SES, or slow learners need differentiated maps. Instead, cartographers should address themselves to overall improvements.

Even with four experimental map designs and a series of separate subtests within the main instrument, it is hardly possible to identify the ideal map design for middle grade pupils. Within the limitations of having tried only four map designs from an infinite number of possibilities, however, one might postulate a composite map which carries a considerable amount of physical-political data, incorporates a prominent and complete legend, compass rose, accentuated lines of latitude and longitude, and has no more than three or four type sizes. Whether the classroom map should be printed in bright, highly contrasting colors or be cast in traditional hues apparently is still a matter of discretion with the cartographer.

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APPENDIX A

DESCRIPTIONS OF EXPERIMENTAL MAPS

Map 1: Traditional Color Scheme and Layout

Feature Shown	Means of Portrayal
Vertical Scale	10 color tints will be used to indicate elevation above sea level or depth of water. A legend marked "Relief" will show each color tint with a scale in meters on the left and in feet on the right.
Horizontal Scale	Projection will be identified as conic and will be essentially equal-area, making direct measurements possible. A statement of the scale (1:4,000,000; one inch to 64 miles) will be provided along the lower edge of the map and a direct reading scale in miles and kilometers will appear at another point along the lower edge.
Direction	No compass rose or other obvious indication of direction will be provided; however, inclusion of lines of latitude and longitude and placing north at the top of the map may be regarded as substitutes for a compass rose.
Location or Grid System	Latitude and longitude lines will be provided at 2 degree intervals; numbers associated with the lines will not carry degree symbols. Words "West Longitude" and "East Longitude" will be provided along bottom edge of map to indicate areas on either side of prime meridian, which will run near the map center.
Physical Features	Yellow, green, and brown color tints will be used for land areas and blue color tints for water areas of the surface. Lakes will be outlined and named; rivers will be marked with a black line, the name, and the word "river" paralleling its course; oceans, seas, gulfs, bays, islands, mountain ranges, mountain peaks, and certain land regions will be identified with the names spread to indicate general location or area.
Political Features	Cities will be marked with dots of different design to indicate population (no legend to show what population is represented by eacy type dot) and by red areas to indicate the extent of the largest urban centers. City populations also will be indicated by the size of type used in their identification (no legend). Nations will be named with bold capital letters spaced to indicate territory; boundaries between nations will be marked with a broad red-orange line.
Overall Design	Map will be kept somewhat simple to make it attractive and perhaps easier to use. Legend data will be minimal and somewhat dispersed, as indicated above. Seven different type sizes and styles will be used on the map. Colors chosen will follow customary "brown for land, blue for water" pattern.

Map 2: Modified Traditional

Feature Shown	Means of Portrayal
Vertical Scale	Same scale and color tint system as Map 1.
Horizontal Scale	Statement that scale is 1:4,000,000 will be eliminated and related statement that 1 inch equals 64 miles will be moved to unified legend (described under Overall Design).
Direction	Same system as Map 1, except grid lines emphasized as described below.
Location or Grid System	Much the same as Map 1, except that grid lines will be extended into margins of the map, degreee will be indicated with slightly larger and bolder numerals than in Map 1, the degree symbol and appropriate word (East, West, or North) will be associated with the numeral, and the degree designation will be high lighted through use of a contrasting color tinted circle as background.
Physical Features	While color tints for marking vertical scale will be the same as in Map 1, a reduction in the number of letter sizes and styles (as noted under Overall Design) will have some effect on labels for physical features on the map.
Political Features	A system of different-shaped symbols will be used to mark the location of cities of different populations and to indicate national capitals. This symbol system will be incorporated into the unified legend to be carried on Map 2.
Overall Design	The number of letter sizes and styles on the map will be reduced from 7 to 3. The unified legend will include a horizontal scale in miles; a vertical scale in feet showing the color tints used to indicate each elevation range; and a set of symbols with short statements indicating what each signifies on the map.

Map 3: Location Map

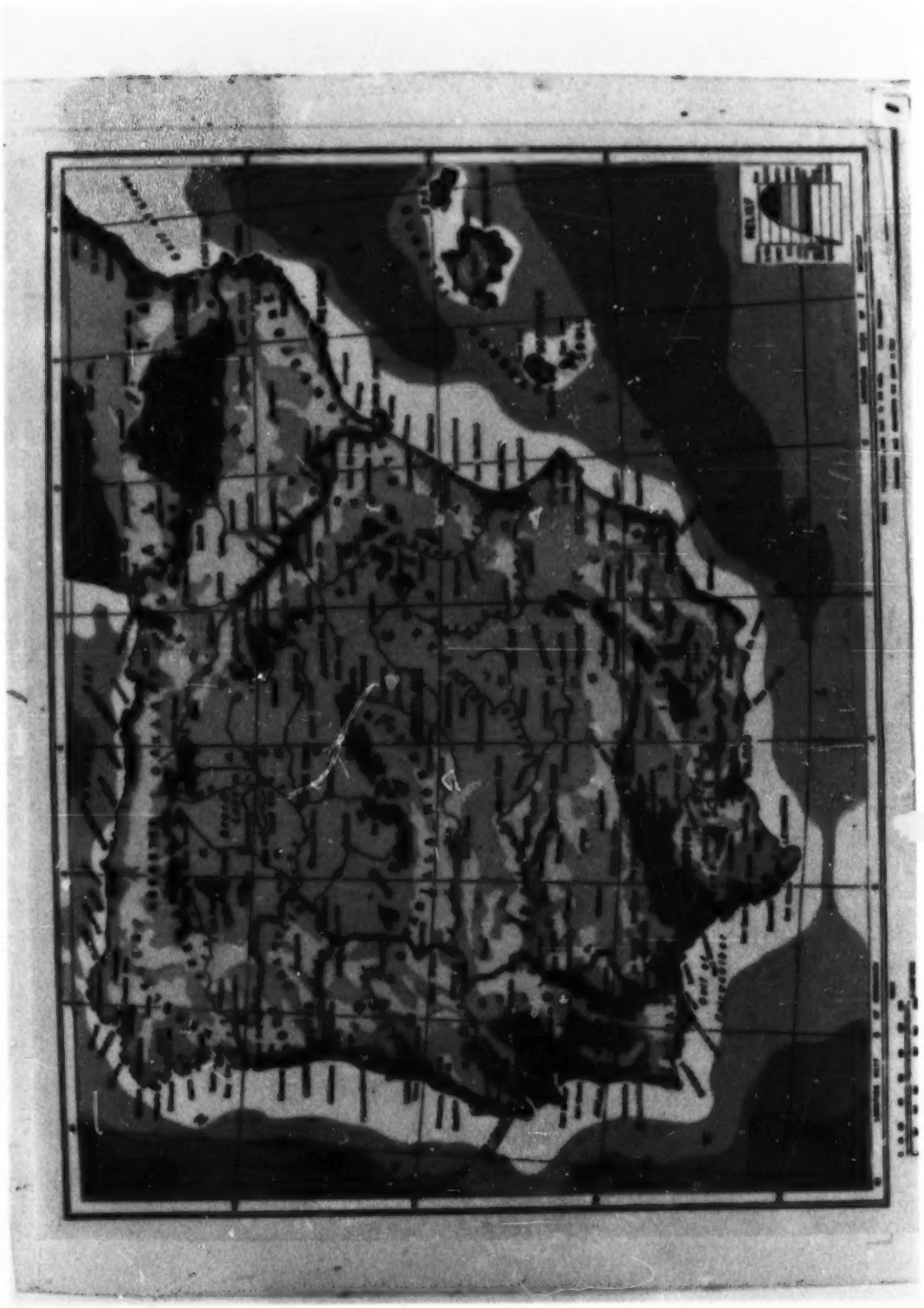
Feature Shown	Means of Portrayal
Vertical Scale	Map will be designed to aid location only, therefore, data on vertical scale will not be included (see hypotheses).
Horizontal Scale	Same as Map 1.
Direction	Prominent compass rose, as in Map 4.
Location or Grid System	Same as Map 1.
Physical Features	Lettering and other identification will be similar to Map 1, except that a single background color (yellow) will be used for land areas. Blue will be used for water areas. It is hypothesized that this color scheme will aid in locating physical features on the map.
Political Features	Same as Map 1, with the exception of background colors (blue for water and yellow for land).
Overall Design	Map 3 will be identical to Map 1, except for the color tine.

Map 4: Non-Traditional, With Highly Contrasting Colors

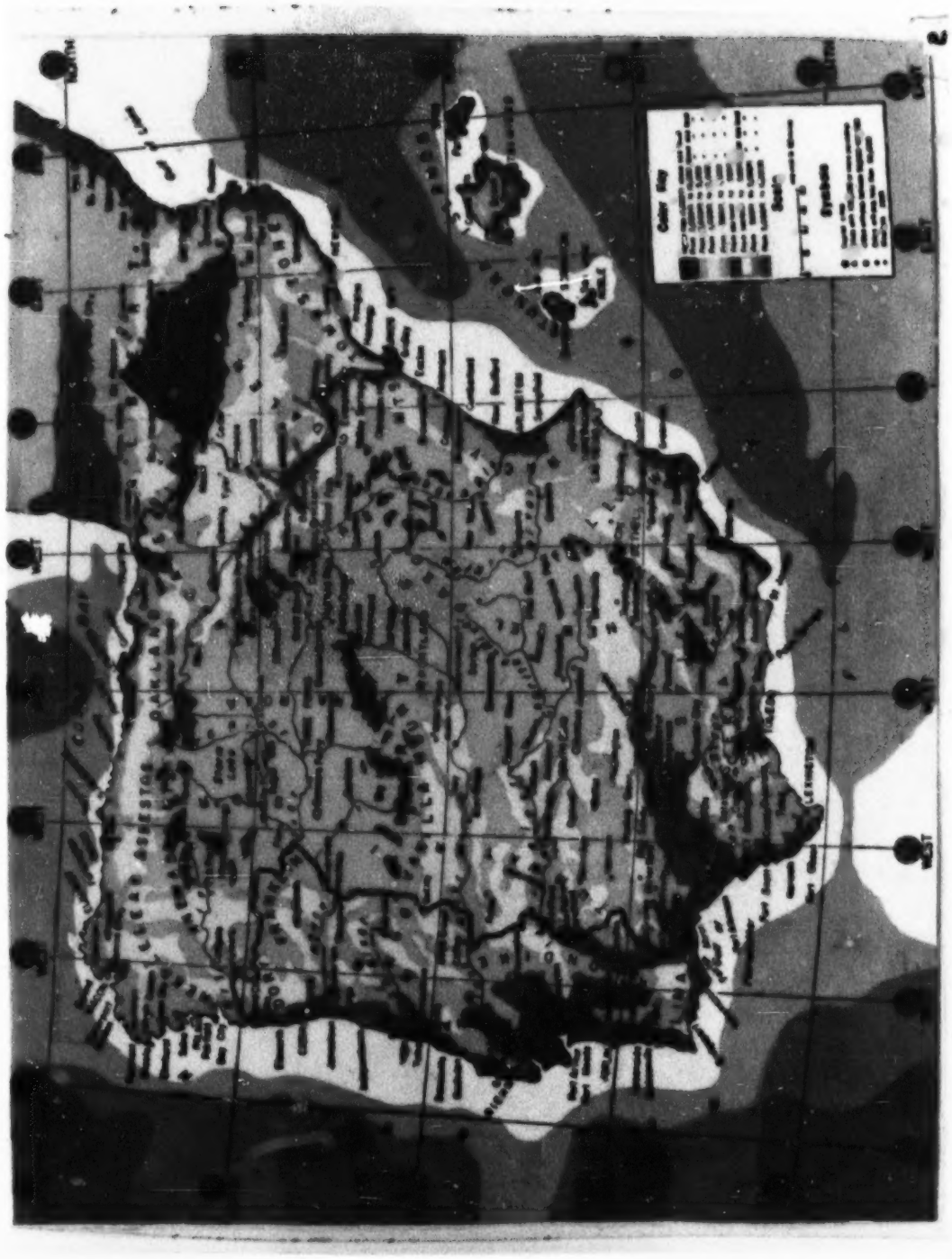
Feature Shown	Means of Portrayal
Vertical Scale	While scale will be the same as in Map 1 and Map 2, highly contrasting and "nonstandard" colors will be used to show elevations and depths. So far as possible, these colors will be chosen with the intent of forcing the map user to refer to the legend, rather than to use intuitive or guessing behavior in response to vertical scale questions.
Horizontal Scale	Essentially the same as in Map 2, with scale in miles a part of the unified legend of the map.
Direction	A compass rose, designed to show up well and prominently placed, will be included.
Location or Grid System	Grid lines will be extended and marked much as in Map 2. Where necessary, grid lines will be made white for contrast with background colors on the map.
Physical Features	Oceans, seas, island groups, bays, and gulfs will be marked with a rectangular "tag" rather than by spreading the letters to cover a certain area. The label will be made prominent through elimination of details within them--in some cases they will be white, at other spots they will use some other background color for maximum contrast. In the case of large areas, such as an ocean or sea, more than one label may be used.
Political Features	National capitals and names of countries will be marked with labels similar to those used for prominent physical features. Cities of large population and area will have, in addition, a contrasting color spot to indicate their areal extent.
Overall Design	As noted above, color tints will be non-traditional, labels will be used to indicate prominent physical and political features of the land, grid lines will be designed to stand out, and a compass rose and legend will be provided.

APPENDIX B

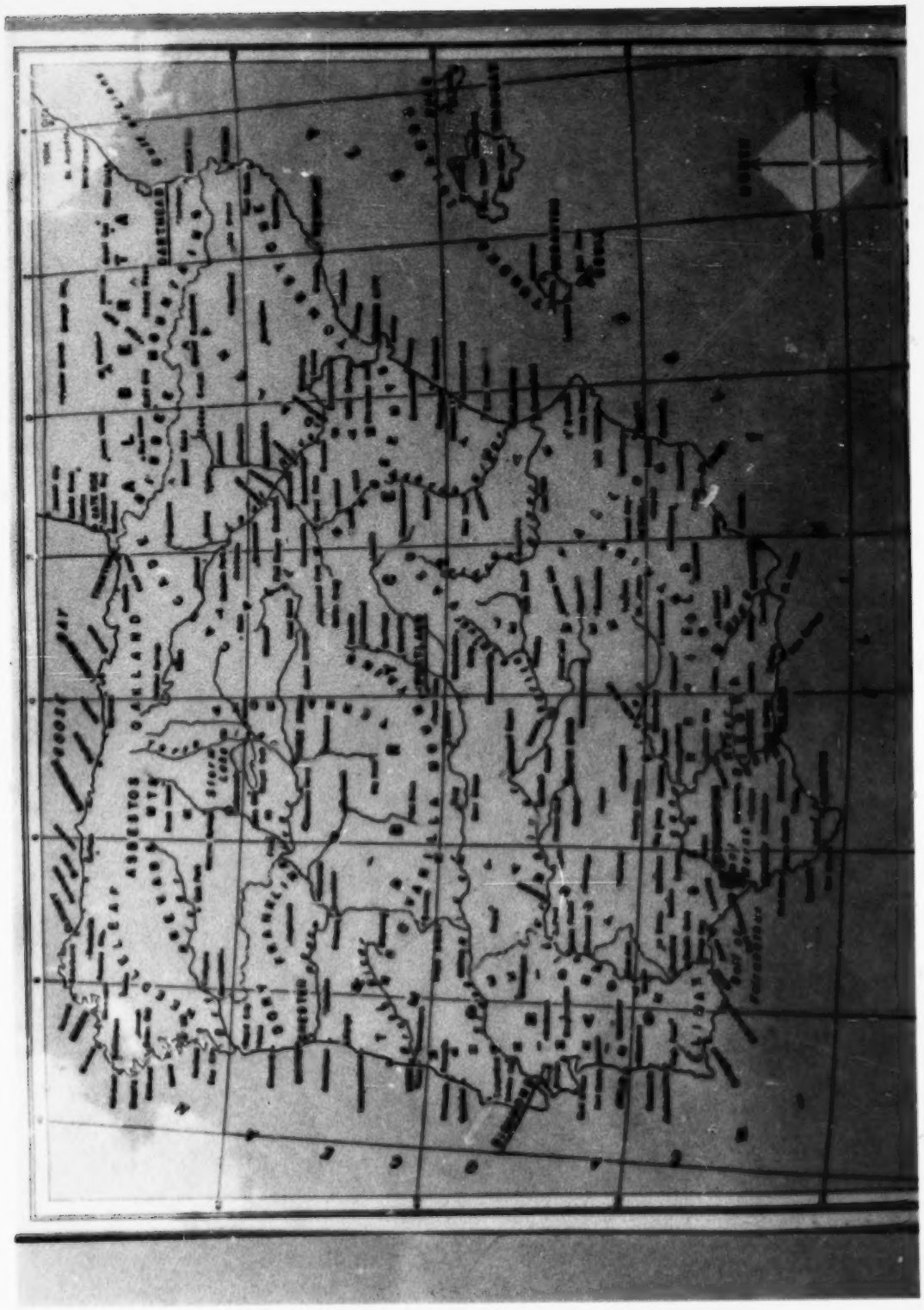
COLOR PHOTOGRAPHS OF MAPS



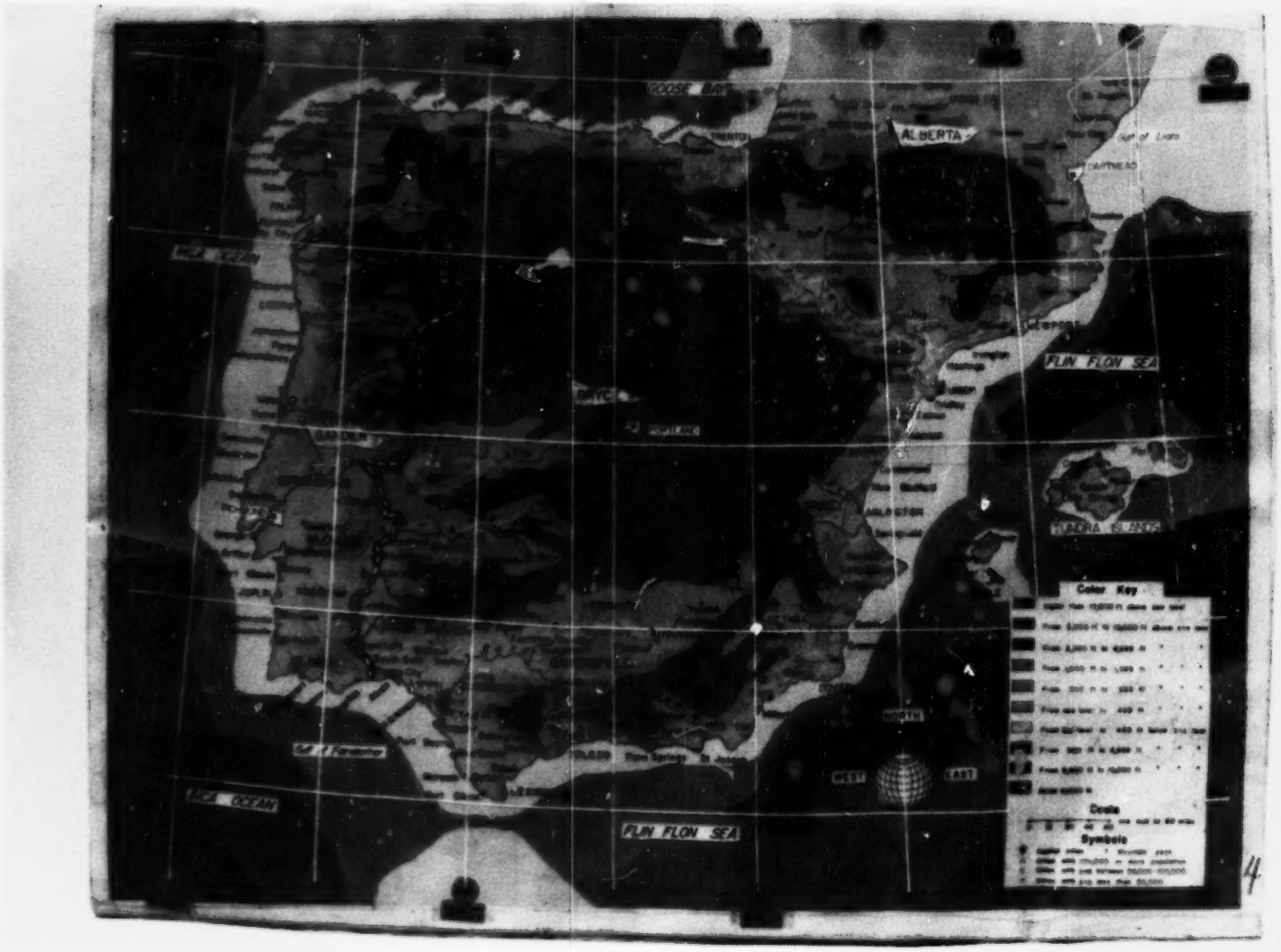
Map 1: Traditional Color Scheme and Layout.



Map 2: Modified Traditional.



Map 3: Location Map.



Map 4: Non-Traditional, with Highly Contrasting Colors.

APPENDIX C

MAP EFFECTIVENESS TESTS

Peabody
Map
Effectiveness
Study

Pupil's Name/S. No._____

Sex/Grade/School_____

Date of Testing_____

General Comments:

SCORE SHEET FOR TEST A

IBM Card Columns			
2-5	__ __ __ __		Pupil Number.
6	1 2 3 4		Test in total sequence. (circle)
7-8	A1 A2 A3 A4		Test and map used. (circle)
9-11			(SKIP)

PUPIL RESPONSES TO TEST QUESTIONS

12	0	1	1. $ Point to and tell me the name of three countries on this map. (Gander, Alberta, Bryce)
13	0	1	2. $ Draw in the boundary between Bryce and Alberta.
14	0	1	3. $ Find and point to the city of Edmundton. (6/37)
15-17	__ __ __ __		4. $(Record search time for question 3, above)
18	0	1	5. % What is the name of the ocean shown on the map?
19-21	__ __ __ __		6. %(Record search time for question 5, above)
22	0	1	7. $ Find and point to the capital of Bryce
23-25	__ __ __ __		8. $(Record search time for question 7, above)
26	0	1	9. % What is the largest mountain range on this map? (Bisbee Mts.)
27	0	1	10. % Locate and point to Dismal Marsh.
28-30	__ __ __ __		11. %(Record search time for question 10, above)
31	0	1	12. % What is the name of the lake found on this map?
32-34	__ __ __ __		13. %(Record search time for question 12, above)

35	0	1	14.	<	What tells you how big a city is on this map? (Symbol, print, configuration)
36	0	1	15.	*	If you were going from Camden (7/38) to Bowling Green (5/38), in what direction would you be going? (East)
37	0	1	16.	%	Find and point to Mt. Pleasant.
38-40	__	__ __	17.	%	(Record search time for question 16, above)
41	0	1	18.	0	Into what body of water does the Peace River empty? (Inca Ocean)
42	0	1	19.	X	How many miles does on inch on this map stand for? (60 or 64)
43	0	1	20.	<	(Point to 40^{o} line) This says 40^{o}, what does this mean? (Latitude-north of Equator)
44	0	1	21.	<	Is there any difference between the printing of this name, Columbus Junction ($4^{o}/39^{o}$), and this name, Harrisburg ($2^{o}W/38^{o}$)? If "yes," why do you think they are printed in different ways? (No)

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45	0	1	22.	*	If you were going from Minorca ($1^{o}W/42^{o}$) to Mt. Rushmore ($1^{o}E/43$), in what direction would you be going? (Northeast)
46	0	1	23.	<	Here you see the name Bakersfield. What does that name? (Province)
47	0	1	24.	<	(Point to color key) How does this help you to read the map? (Explains elevation)

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48	0	1	25.	Σ	At what longitude is Flint? ($6^{o}W$)
49	0	1	26.	X	How far is it from Greensboro (8/40) to Quincy (7/40)? (85-95)

50	0	1	27.	$ What city is larger, York (9/40) or Gadsden (9/39)? York
51	0	1	28.	Σ At what latitude is Storm Lake? (42^{o} North)
52	0	1	29.	0 What do you think the red means on the map? (2000-4999)
53	0	1	30.	$ Which city is larger, Evanstown (1/41) or Minorca (0/42)? (Minorca)
54	0	1	31.	0 Which city is higher, Anderson (0/40) or Appleton (5/38)? (Anderson)
55	0	1	32.	* If you were going from Bridgeport (9/37) to Macon (8/43), in what direction would you be going? (North)
56	0	1	33.	X How many miles is the island of Noble from the nearest mainland? (55-65 mi.)
57	0	1	34.	Σ What gulf is nearest the intersection of 4^{o} east longitude and 43^{o} north latitude? (Gulf of Lions)
58	0	1	35.	0 What is the elevation of Bethlehem? (9/43) (500-999)
59	0	1	36.	* In what direction from Richmond (9/39) is Wamsutter (8/38)? (Southeast)
60	0	1	37.	Σ What city is located near the intersection of 4^{o} west longitude and 42^{o} north latitude? (Elmfork)
61	0	1	38.	< (Point to configuration) What does this mean? (Large, important city)
				_____
				_____
				_____
62	0	1	39.	X Which is farther, from Portland to Hammond (3/41), or from Portland to Troy (5/40)? (Portland to Troy)
63	0	1	40.	0 Which has deeper water, the Gulf of Lions, or Goose Bay? (Goose Bay)
64	0	1	41.	0 What is the elevation of Blue Haven (0/43) (1000-1999)

65	0	1	42.	* What direction is Burbank (5/41) from Portland? (Northwest)
66	0	1	43.	X How many miles is it from LaGrange (7/38) to Chesterfield ($6^{o}W/39^{o}$)?
67	0	1	44.	Σ What place is located at 1^{o} west longitude and 39^{o} north latitude? (Cranston)
68	0	1	45.	* If you were going from Columbus Junction ($4^{o}W/39^{o}$) to Ogden ($5^{o}W/39$), in what direction would you be going? (West)
69	0	1	46.	Σ What city is located nearest the intersection of 4^{o} west longitude and 43^{o} north latitude? (Sulphur Springs)
70	0	1	47.	X How many miles is it from Wheeling ($3^{o}W/41^{o}$) to Brownsville ($0^{o}/40^{o}$)? (175-185 miles)
71	0	1	48.	% Describe for me what you think this area is like: Between 2^{o} and 4^{o} (west) and 38^{o} and 40^{o} (north)

Peabody
Map
Effectiveness
Study

Pupil's Name/S. No._____

Sex/Grade/School_____

Date of Testing_____

General Comments:

SCORE SHEET FOR TEST B

IBM Card Columns			
2-5	__ __ __ __		Pupil number.
6	1 2 3 4		Test in total sequence. (circle)
7-8	B1 B2 B3 B4		Test and map used. (circle)
9-11			(SKIP)

PUPIL RESPONSES TO TEST QUESTIONS

12	0	1	1. $ What is the name of this country? (Point to Gander) (Gander)
13	0	1	2. $ Draw in the boundary between Bryce and Alberta.
14	0	1	3. $ Find and point to Union City.
15-17	__ __ __ __		4. $(Record search time for question 3, above)
18	0	0	5. % What is the name of a gulf shown on the map?
19-21	__ __ __ __		6. %(Record search time for question 5, above)
22	0	1	7. $ Richmond is the capital of what country? (Gander)
23	0	1	8. % Here is Oak Park. What is the name of the mountain range nearest Oak Park? (Nevada Mts.)
24	0	1	9. % Locate and point to Goose Bay.
25-27	__ __ __ __		10. %(Record search time for question 9, above)
28	0	1	11. % What is the name that goes with this line? (Point to unlabeled segment of the Leaf River)
29	0	1	12. < What tells you how big a city is on this map? (Circles, configuration, print)

30	0	1	13.	* If you were going from Scranton (1/39) to Newton (3/39) in what direction would you be going? (West)
31	0	1	14.	% Find and point to Mt. Rose.
32	__ __ __ __		15.	%(Record search time for question 14, above)
33	0	1	16.	0 What is the elevation of Topeka? (1,000-2,000')
34	0	1	17.	X How many miles from Arlington (0/39) to Neversink (E3/39)? (187-197 miles)
35	0	1	18.	< (Point to 38°N line) This says 38°; what does this mean? (North latitude, north of equator)
36	0	1	19.	< How many different sizes of printing are on this map? (7)
37	0	1	20.	* If you were going from Troy (5°W/40°) to Florence (3°W/38°), in what direction would you be going? (Southeast)
38	0	1	21.	< Here you see the name Tracy. What does that name? (Province)
39	0	1	22.	< (Point to Scale) How does this help you to read the map? (Helps tell distance)
40	0	1	23.	Σ At what longitude is Newport? (2° East)
41	0	1	24.	X How many miles is it from Sydney (6°W/37°) to Batesburg (5°W/37°)? (55-65 miles)
42	0	1	25.	$ Which city is larger, Troy (5°/40°) or Kokomo (5°/40°)? (Troy)
43	0	1	26.	Σ At what latitude is Fresno? (42° North)
44	0	1	27.	0 What do you think the light green stands for on this map?

45	0	1	28.	$ Which city is larger, Hartford ($1^{o}E/42^{o}$) or Fresno ($3^{o}E/42^{o}$)? (Fresno)
46	0	1	29.	0 Which city is higher, Portland or Richmond? (Portland)
47	0	1	30.	* If you were going from Chesterfield ($5^{o}W/39^{o}$) to Glasgow ($7^{o}W/41^{o}$), in what direction would you be going? (Northwest)
48	0	1	31.	X How many miles is it from Macon ($8^{o}W/43^{o}$) to Hamilton ($4^{o}W/43^{o}$)? (175-185 miles)
49	0	1	32.	Σ What gulf is nearest the intersection of 7^{o} west longitude and 37^{o} north latitude? (Gulf of Fairweather)
50	0	1	33.	0 What is the elevation of Pine Bluff? ($3^{o}W/39^{o}$) 2000'-5000')
51	0	1	34.	* Dixon (4/37) is what direction from Hickory (1/39)? (Southwest)
52	0	1	35.	Σ What city is located nearest to the intersection of 4^{o} east longitude and 40^{o} north latitude? (Fort Smith)
53	0	1	36.	< (Point to configuration) What does this mean? (Indicates large city)
54	0	1	37.	X Which is farther, from Newport (E2/41) to Dartmead (E3/43), or from Newport (E2/41) to Mount Rushmore? (Dartmead)
55	0	1	38.	0 What is the depth of the water at 38^{o} and between $2^{o}E$ and $4^{o}E$? (5,000-10,000)
56	0	1	39.	0 What is the elevation of Cliff City? ($0^{o}/43^{o}$) (5000-10,000)
57	0	1	40.	* Deadwood (5/41) is what direction from Rome (7/39)? (Northeast)
58	0	1	41.	X How far is it from Waterbury (5/38) to Columbus Junction (3/39)? (55-65 miles)
59	0	1	42.	Σ What island is nearest the intersection of 3^{o} east longitude and 39^{o} north latitude? (Trinidad)

60	0	1	43.	* What city in Gander is the farthest south? (Kalamazoo)
61	0	1	44.	Σ What mountain peak is at 1^{o} west longitude and 43^{o} north latitude? (Mt. Rose)
62	0	1	45.	X How many miles is it from Jackson ($2^{o}W/42^{o}$) to Clarksville ($1^{o}W/42^{o}$)? (55-65 miles)
63	0	1	46.	% Describe for me what you think this area is like: Between 6^{o} and 8^{o} (west) and 36^{o} and 38^{o} (north).

_____

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_____

Peabody
Map
Effectiveness
Study

Pupil's Name/S. No._____

Sex/Grade/School_____

Date of Testing_____

General Comments:

SCORE SHEET FOR TEST C

IBM Card Columns		
2-5	__ __ __ __	Pupil Number.
6	1 2 3 4	Test in total sequence. (circle)
7-8	C1 C2 C3 C4	Test and map used. (circle)
9-11		(SKIP)

PUPIL RESPONSES TO TEST QUESTIONS

12	0	1	1. $ What is the name of this country on this map? (Point to Alberta)
13	0	1	2. $ Draw in the northern boundary of Gander.
14	0	1	3. $ Find and point to South Bend.
15-17	__ __ __ __		4. $ (Record search time for question 3, above)
18	0	1	5. % What is the name of the sea shown on the map? (Flin Flon)
19-21	__ __ __ __		6. % (Record search time for question 5, above)
22	0	1	7. $ Find and point to the capital of Alberta.
23-25	__ __ __ __		8. $ (Record search time for question 7, above)
26	0	1	9. % Here is Portland. What is the name of the mountain range nearest Portland? (Vanilla)
27	0	1	10. % Find and point to Rocky Peak.
28-30	__ __ __ __		11. % (Record search time for question 10, above)
31	0	1	12. % What is the name that goes with this line? (Point to unlabeled segment of Slave River)

32	0	1	13.	< What tells you how big a city is on this map? (symbol, print)
33	0	1	14.	* If you were going from Pittsfield (4/39 to Norfolk (0/39), in what direction would you be going? (East)
34	0	1	15.	% Locate and point to the Gulf of Lions.
35-37	__ __ __ __		16.	% (Record search time for question 15, above)
38	0	1	17.	0 Which way does the Leaf River flow, toward Reno or toward Evanstown? (Evanstown)
39	0	1	18.	X What does this graph tell us? (Point to Scale)
40	0	1	19.	< (Point to 38° line) This says 38°, what does this mean? (North of Equator)
41	0	1	20.	< Is there any difference between the printing of this name Fresno (3°E/42°), and this name, Dartmead (3°E/43°)? If "yes," why do you think they are printed in different ways? (Yes)
42	0	1	21.	* If you were going from Rockford (2/37) to Trenton (2/43), in what direction would you be going? (North)
43	0	1	22.	< Here you see the name Climax. What does that name? (Province, State, County)
44	0	1	23.	< (Point to Relief) How does this help you to read the map?

45	0	1	24.	Σ At what longitude is Storm Lake? (5^{o}W)
46	0	1	25.	X How far is it from Edmundton (6/37) to Toledo (5/37)? (85-95 miles)
47	0	1	26.	$ Which city is larger, Minorca (1E/42) or Newport (E2/41)? (Newport)
48	0	1	27.	Σ At what latitude is Joplin? (38^{o}N)
49	0	1	28.	0 What color is used to show the highest mountain?
50	0	1	29.	$ Which city is larger, Arlington (0/39) or Springfield (0/39)? (Arlington)
51	0	1	30.	0 Which city is higher, Lynn (6/39) or Camden (8/38)? (Lynn)
52	0	1	31.	* If you were going from Harrison (7^{o}W/38^{o}) to Darby (3^{o}W/40^{o}) in what direction would you be going? (Northeast)
53	0	1	32.	X How many miles from Union City (E1/41) to Canton Hills, Trinidad? (115-125 miles)
54	0	1	33.	Σ What city is located nearest the intersection of 9^{o} west longitude and 39^{o} north latitude? (Richmond)
55	0	1	34.	0 What is the elevation of Western Springs (6/42) (2000'-5000')
56	0	1	35.	* What direction is Blue Ridge (7/39) from Boulder City (5/37)? (Northwest)
57	0	1	36.	Σ What city is located nearest the intersection of 3^{o} east longitude and 43^{o} north latitude? (Dartmead)
58	0	1	37.	< (Point to configuration) What does this mean?
				_____
				_____
				_____
59	0	1	38.	X Which is farther, from Portland to Mount Hood, or from Portland to Mount Rushmore? (Mount Rushmore)

60	0	1	39.	0 Which has deeper water, Flin Flon Sea, or the Inca Ocean? (Inca Ocean)
61	0	1	40.	0 What is the elevation of Granger? (9/39) (Sea level-500')
62	0	1	41.	* Kalamazoo (8/37) is what direction from Newport News (5/39)? (Southwest)
63	0	1	42.	X How many miles is it from Belter (5^{o}W/39^{o}) to Augusta (2^{o}W/39^{o}) (175-185 miles)
64	0	1	43.	Σ What place is nearest 1^{o} east longitude and 41^{o} north latitude? (Hastings)
65	0	1	44.	* If you were going from Barnesville (3^{o}W/39^{o}) to Slate (1^{o}W/37^{o}), in what direction would you be going? (Southeast)
66	0	1	45.	Σ What city is located nearest to the intersection of 2^{o} east longitude and 42^{o} north latitude? (Ida Grove)
67	0	1	46.	X How many miles is it from Troy (6^{o}W/40^{o}) to Westminister (3^{o}W/40^{o})? (115-125)
68	0	1	47.	% Describe for me what you think this area is like: Between 8^{o} and 10^{o} (West) and 38^{o} and 40^{o} (North)

_____

_____

_____

Peabody
Map
Effectiveness
Study

Pupil's Name/S. No._____

Sex/Grade/School_____

Date of Testing_____

General Comments:

SCORE SHEET FOR TEST D

IBM Card Columns		
2-5	__ __ __ __	Pupil number.
6	1 2 3 4	Test in total sequence. (circle)
7-8	D1 D2 D3 D4	Test and map used. (circle)
9-11		(SKIP)

PUPIL RESPONSES TO TEST QUESTIONS

12	0	1	1. $ What is the name of this country? (Point to Bryce)
13	0	1	2. $ Draw in the eastern boundary of Gander.
14	0	1	3. $ Find and point to the city of Union City. (1/41).
15-17	__ __ __ __		4. $ (record search time for question 3, above)
18	0	1	5. % What is the name of the bay shown on the map?
19-21	__ __ __ __		6. % (Record search time for question 5, above)
22	0	1	7. $ Find and point to the capital of Gander.
23-25	__ __ __ __		8. $ (Record search time for question 7, above)
26	0	1	9. % Find and point to Mount Rushmore.
27-29	__ __ __ __		10. % (Record search time for question 9, above)
30	0	1	11. % Here is Toledo. What is the name of the mountain range nearest Toledo? (Sierra Mts.)
31	0	1	12. % What is the name that goes with this line? (Point to unlabeled segment of the Sand River)

32	0	1	13.	< What tells you how big a city is on this map?
33	0	1	14.	* If you were going from Kokomo (5^{o}W/40^{o}) to Oakpark (7^{o}W/43^{o}) in what direction would you be going? (Northwest)
34	0	1	15.	% Locate and point to the Gulf of Fairweather.
35-37	__	__ __	16.	% (Record search time for question 15, above)
38	0	1	17.	0-% Which way does the Mud River flow, toward Dixon or toward Beaufort? (Toward Beaufort)
39	0	1	18.	X How many miles does one inch on this map represent? (60)
40	0	1	19.	< (Point to 36^{o}N line) This says 36^{o} north. What does this mean? (North latitude, north of equator)

_____

_____

_____

41	0	1	20.	< How many different sizes of printing are on this map?
42	0	1	21.	* If you were going from Brentwood (2^{o}W/42) to Oakbrook (6^{o}W/40) in what direction would you be going? (Southwest)
43	0	1	22.	< Here you see the name Oakland. What does that name? (Province)
44	0	1	23.	< (Point to Scale) How does this help you to read the map? (helps determine distance)

_____

_____

_____

45	0	1	24.	Σ At what longitude is Trenton? (2^{o} West)
46	0	1	25.	X How far is it from Newport (2/41) to Ida Grove (2/42)? (60-65 mi.)
47	0	1	26.	$ Which city is larger, Southgate (7^{o}/37^{o}) or Sydney (6^{o}/37^{o})? (Sydney)

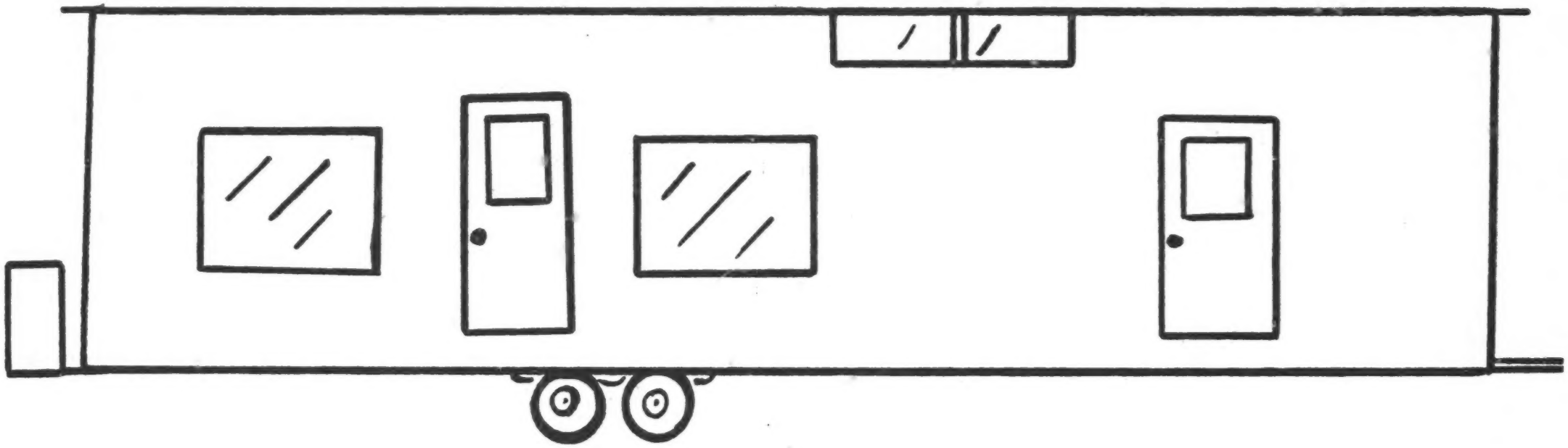
48	0	1	27.	Σ At what latitude is Bethel? (38° North)
49	0	1	28.	0 What do you think the ___green___ represents on this map?
50	0	1	29.	$ Which city is larger, Troy (5°W/37°) or Lexington (6°W/36°)? (Lexington)
51	0	1	30.	0 Which city is higher, Promise City (7/43) or Western Springs (6/43)? (Western Springs)
52	0	1	31.	* If you were going from Palm Beach (3/39) to New Bedford (0/39) in what direction would you be going? (West)
53	0	1	32.	X How many miles from Neversink (E3/39) to Fort Smith (E4/40)? (60-65)
54	0	1	33.	Σ What city is located nearest to the intersection of 6° west longitude and 36° north latitude? (Fort Gibson)
55	0	1	34.	0 What is the elevation of Youngstown? (5/37) (500-1000 ft.)
56	0	1	35.	* In what direction from Battle Creek (3/41) is Dexter (1/40)? (Southeast)
57	0	1	36.	Σ What city is located nearest the intersection of 9° west longitude and 41° north latitude? (Jamestown)
58	0	1	37.	< (Point to square) What does this mean? (City has population of 50,000 and 100,000)
59	0	1	38.	X Which is farther, from Portland to Chester (9/41), or from Portland to Edmundton (6/37)? (Portland to Chester)
60	0	1	39.	0 Which has deeper water, the water surrounding Noble Island, or Storm Lake? (Around Noble Island)
61	0	1	40.	0 What is the elevation of Darby? 3/40) (2000-5000 ft.)

62	0	1	41.	* What city in Bryce is the farthest south? (Fort Gibson)
63	0	1	42.	X How many miles is it from Quincy (7^{o}W/40^{o}) to Kokomo (5^{o}W/40^{o})? (115-125)
64	0	1	43.	X What mountain peak is nearest the intersection of 3^{o} west longitude and 37^{o} north latitude? (Mt. Hood)
65	0	1	44.	* Arlington (1/39) is what direction from Rockford (2/37)? (Northeast)
66	0	1	45.	Σ What place is nearest 1^{o} east longitude and 43^{o} north latitude? (Flint Falls)
67	0	1	46.	X How many miles is it from Richmond to Oshkosh (5^{o}W/39^{o})? (175-185)
68	0	1	47.	% Describe for me what you think this area is like: Between 0^{o} and 2^{o} (east) and 42^{o} and 44^{o} (north)

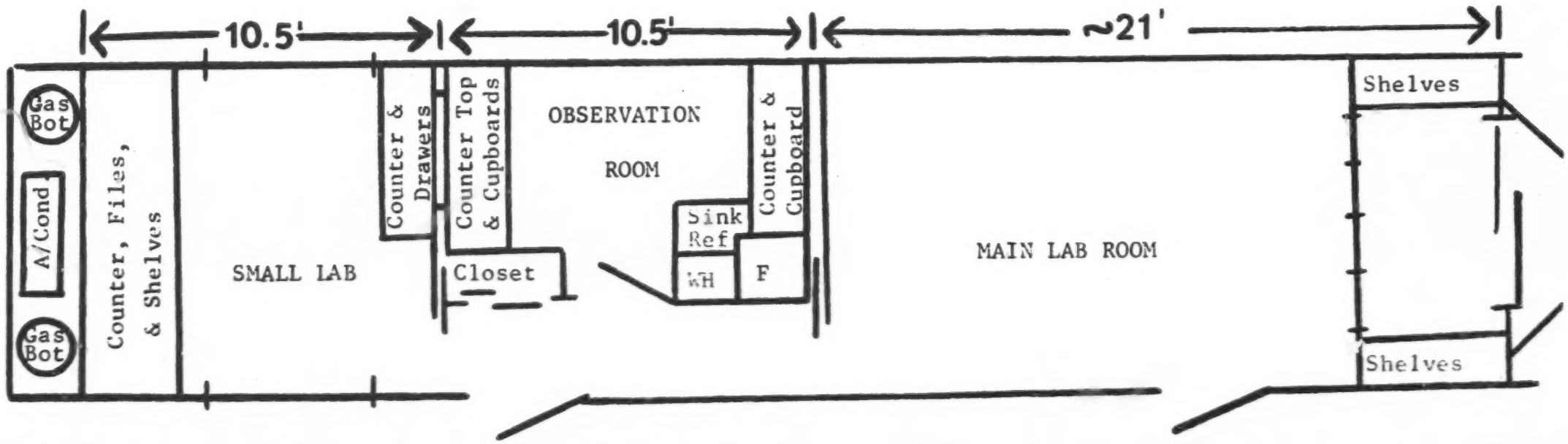
APPENDIX D

DRAWING OF MOBILE LABORATORY

1" = 5'



44'


10.5'
10.5'
~21'
Gas Bot
A/Cond
Gas Bot
Counter, Files, & Shelves
SMALL LAB
Counter & Drawers
Counter Top & Cupboards
Closet
OBSERVATION ROOM
Sink
Ref
WH
F
Counter & Cupboard
MAIN LAB ROOM
Shelves
Shelves

APPENDIX E

ANALYSIS OF VARIANCE TABLES

Table 1

Analysis of Variance for H-1, Controlled for Grade Level and SES of Subjects (Maps 1 and 2 vs. Map 4)

Source	df	Sum of Squares	Mean Squares	F-Ratios
Between Subjects	95	1691.813	17.809	
SES (B)	1	165.021	165.021	14.42**[1]
Grade Level (C)	2	459.406	229.703	20.07**[2]
B X C	2	37.385	18.693	1.63
Between Ss Error	90	1030.000	11.444	
Within Subjects	96	383.000	3.990	
Map Scores (A)	1	7.521	7.521	1.88
A X B	1	3.521	3.521	.88
A X C	2	10.073	5.036	1.26
A X B X C	2	1.885	.943	.24
Within Ss Error	90	360.000	4.000	
Total	191	2074.813	10.863	

**Significant at the .01 level.

1. High SES > Low SES.
2. Grade 6 > Grade 4.

Table 2

Analysis of Variance for H-1, Controlled for Grade Level and Sex of Subjects (Maps 1 and 2 vs. Map 4)

Source	df	Sum of Squares	Mean Squares	F-Ratios
Between Subjects	89	1644.980	18.483	
Sex (B)	1	7.203	7.203	.51
Grade Level (C)	2	436.480	218.240	15.55**[1]
B X C	2	22.431	11.215	.80
Between Ss Error	84	1178.867	14.034	
Within Subjects	90	357.000	3.967	
Map (A)	1	5.003	5.003	1.22
A X B	1	1.420	1.420	.35
A X C	2	6.697	3.349	.82
A X B X C	2	.214	.107	.03
Within Ss Error	84	343.667	4.091	
Total	179	2001.980	11.184	

**Significant at the .01 level.

1. Grades 6, 5 > Grade 4.

Table 3

Analysis of Variance for H-1, Controlled for Grade Level and I.Q. of Subjects (Maps 1 and 2 vs. Map 4)

Source	df	Sum of Squares	Mean Squares	F-Ratios
Between Subjects	44	760.559	17.285	
I.Q. (B)	2	216.625	108.313	13.27**[1]
Grade Level (C)	2	220.359	110.179	13.50**[2]
B X C	4	29.775	7.444	.91
Between Ss Error	36	293.800	8.161	
Within Subjects	45	139.500	3.100	
Map (A)	1	16.903	16.903	6.38*[3]
A X B	2	11.464	5.732	2.16
A X C	2	8.264	4.132	1.56
A X B X C	4	7.470	1.867	.70
Within Ss Error	36	95.400	2.650	
Total	89	900.059	10.113	

*Significant at .05 level.
**Significant at .01 level.

1. High I.Q. > Average I.Q. > Low I.Q.
2. Grade 6 > Grade 5 > Grade 4.
3. Map 4 > Maps 1-2.

Table 4

Analysis of Variance for H-1 Controlled for Grade Level and Iowa Map Test Scores of Subjects (Maps 1 and 2 vs. Map 4)

Source	df	Sum of Squares	Mean Squares	F-Ratios
Between Subjects	47	748.336	15.922	
Iowa Map Test (B)	3	277.586	92.529	11.41**[1]
Grade Level (C)	2	136.648	68.324	8.42**[2]
B X C	6	42.102	7.017	.87
Between Ss Error	36	292.000	8.111	
Within Subjects	48	207.000	4.313	
Map (A)	1	.669	.669	.15
A X B	3	13.581	4.527	1.02
A X C	2	5.143	2.572	.58
A X B X C	6	27.607	4.601	1.04
Within Ss Error	36	160.000	4.444	
Total	95	955.336	10.056	

**Significant at the .01 level.

1. Iowa upper 1/2 > next 1/4 > lowest 1/4.
2. Grade 6,5 > Grade 4.

Table 5

Analysis of Variance for H-2, Controlled for Grade Level and SES of Subjects (Maps 1 and 3 vs. Maps 2 and 4)

Source	df	Sum of Squares	Mean Squares	F-Ratios
Between Subjects	95	1296.121	13.643	
SES (B)	1	35.882	35.882	3.50
Grade Level (C)	2	318.637	159.318	15.54**[1]
B X C	2	18.759	9.380	.91
Between Ss Error	90	922.844	10.254	
Within Subjects	96	320.500	3.339	
Map (A)	1	73.757	73.757	28.71**[2]
A X B	1	3.796	3.796	1.48
A X C	2	8.509	4.255	1.66
A X B X C	2	3.220	1.610	.63
Within Ss Error	90	231.219	2.569	
Total	191	1616.621	8.464	

**Significant at the .01 level.

1. Grade 6 > Grade 5 > Grade 4.
2. Maps 2-4 > Maps 1-3.

Table 6

Analysis of Variance for H-2, Controlled for Grade Level and Sex of Subjects (Maps 1 and 3 vs. Maps 2 and 4)

Source	df	Sum of Squares	Mean Square	F-Ratios
Between Subjects	89	1254.645	14.097	
Sex (B)	1	62.422	62.422	5.89*[1]
Grade Level (C)	2	298.211	149.106	14.08**[2]
B X C	2	4.478	2.239	.21
Between Ss Error	84	889.533	10.590	
Within Subjects	90	307.000	3.411	
Map (A)	1	64.800	64.800	23.62**[3]
A X B	1	.555	.555	.20
A X C	2	9.700	4.850	1.77
A X B X C	2	1.478	.739	.27
Within Ss Error	84	230.467	2.744	
Total	179	1561.645	8.724	

*Significant at the .05 level.
**Significant at the .01 level.

1. Males > Females.
2. Grades 6,5 > Grade 4.
3. Maps 2-4 > Maps 1-3.

Table 7

Analysis of Variance for H-2, Controlled for Grade Level and I.Q. of Subjects (Maps 1 and 3 vs. Maps 2 and 4)

Source	df	Sum of Squares	Mean Square	F-Ratios
Between Subjects	44	671.822	15.269	
I.Q. (B)	2	118.422	59.211	7.98**[1]
Grade Level (C)	2	205.622	102.811	13.86**[2]
B X C	4	80.778	20.194	2.72
Between Ss Error	36	267.000	7.417	
Within Subjects	45	136.000	3.022	
Map (A)	1	23.511	23.511	9.86**[3]
A X B	2	2.022	1.011	.42
A X C	2	10.556	5.278	2.21
A X B X C	4	14.111	3.528	1.48
Within Ss Error	36	85.800	2.383	
Total	89	807.822	9.077	

**Significant at the .01 level.

1. High, Average IQ > Low IQ.
2. Grade 6 > Grade 5 > Grade 4.
3. Maps 2-4 > Maps 1-3.

Table 8

Analysis of Variance for H-2, Controlled for Grade Level and Iowa Map Test Scores of Subjects (Maps 1 and 3 vs. Maps 2 and 4)

Source	df	Sum of Squares	Mean Square	F-Ratios
Between Subjects	47	686.990	14.617	
Iowa Map Test (B)	3	138.031	46.010	4.52**[1]
Grade Level (C)	2	113.021	56.510	5.55**[2]
B X C	6	69.562	11.594	1.14
Between Ss Error	36	366.375	10.177	
Within Subjects	48	114.500	2.385	
Map (A)	1	14.261	14.261	6.35*[3]
A X B	3	10.281	3.427	1.53
A X C	2	.646	.323	.14
A X B X C	6	8.438	1.406	.63
Within Ss Error	36	80.875	2.247	
Total	95	801.490	8.437	

*Significant at the .05 level.
**Significant at the .01 level.

1. Iowa upper 1/4 > Iowa lower 1/2.
2. Grades 6 > Grade 5 > Grade 4.
3. Maps 2-4 > Maps 1-3.

Table 9

Analysis of Variance for H-3, Controlled for Grade Level and SES of Subjects (Map 1 vs. Map 2)

Source	df	Sum of Squares	Mean Square	F-Ratios
Between Subjects	95	646.078	6.801	
SES (B)	1	2.755	2.755	.44
Grade Level (C)	2	71.531	35.766	5.65**[1]
B X C	2	1.760	.880	.14
Between Ss Error	90	570.031	6.334	
Within Subjects	96	89.500	.932	
Map (A)	1	4.380	4.380	4.82*[2]
A X B	1	.047	.047	.05
A X C	2	1.760	.880	.97
A X B X C	2	1.531	.766	.84
Within Ss Error	90	81.781	.909	
Total	191	735.578	3.851	

*Significant at the .05 level.
**Significant at the .01 level.

1. Grades 6, 5 > Grade 4.
2. Map 1 > Map 2.

Table 10

Analysis of Variance for H-3, Controlled for Grade Level and Sex of Subjects (Map 1 vs. Map 2)

Source	df	Sum of Squares	Mean Squares	F-Ratios
Between Subjects	89	637.000	7.157	
Sex (B)	1	1.089	1.089	.16
Grade Level (C)	2	75.100	37.550	5.64**[1]
B X C	2	1.811	.906	.14
Between Ss Error	84	559.000	6.655	
Within Subjects	90	88.000	.978	
Map (A)	1	5.000	5.000	5.28*[2]
A X B	1	.022	.022	.02
A X C	2	1.633	.817	.86
A X B X C	2	1.811	.906	.96
Within Ss Error	84	79.533	.947	
Total	179	725.000	4.050	

*Significant at the .05 level.
**Significant at the .01 level.

1. Grades 6, 5 > Grade 4.
2. Map 1 > Map 2.

Table 11

Analysis of Variance for H-3, Controlled for Grade Level and I.Q. of Subjects (Map 1 vs. Map 2)

Source	df	Sum of Squares	Mean Squares	F-Ratios
Between Subjects	44	285.956	6.499	
I.Q. (B)	2	64.422	32.211	9.15**[1]
Grade Level (C)	2	55.089	27.544	7.82**[2]
B X C	4	39.644	9.911	2.81
Between Ss Error	36	126.800	3.522	
Within Subjects	45	30.000	.667	
Map (A)	1	1.111	1.111	1.54
A X B	2	.289	.144	.20
A X C	2	1.089	.544	.75
A X B X C	4	1.511	.378	.52
Within Ss Error	36	26.000	.722	
Total	89	315.956	3.550	

**Significant at the .01 level.

1. High IQ > Average IQ > Low IQ.
2. Grade 6 > Grade 5 > Grade 4.

Table 12

Analysis of Variance for H-3, Controlled for Grade Level and Iowa Map Test Scores of Subjects (Map 1 vs. Map 2)

Source	df	Sum of Squares	Mean Squares	F-Ratios
Between Subjects	47	327.490	6.968	
Iowa Map Test (B)	3	112.865	37.622	9.24
Grade Level (C)	2	35.083	17.543	4.31
B X C	6	32.917	5.486	1.35
Between Ss Error	36	146.625	4.073	
With Subjects	48	42.500	.885	
Map (A)	1	.511	.511	1.04
A X B	3	7.031	2.344	4.79
A X C	2	.583	.292	.60
A X B X C	6	16.750	2.792	5.70**
Within Ss Error	36	17.625	.490	
Total	95	369.990	3.895	

**Significant at the .01 level.

Table 13

Analysis of Variance for H-4, Controlled for Grade Level and SES of Subjects (Maps 1 and 2 vs. Maps 3 and 4)

Source	df	Sum of Squares	Mean Squares	F-Ratios
Between Subjects	95	2134.996	22.474	
SES (B)	1	26.257	26.257	1.32
Grade Level (C)	2	316.574	158.287	7.96**[1]
B X C	2	3.259	1.630	.08
Between Ss Error	90	1788.906	19.877	
Within Subjects	96	475.500	4.953	
Map (A)	1	47.007	47.007	10.24**[2]
A X B	1	3.254	3.254	.71
A X C	2	10.822	5.411	1.18
A X B X C	2	1.262	.631	.14
Within Ss Error	90	413.156	4.591	
Total	191	2610.496	13.668	

**Significant at the .01 level.

1. Grade 6 > Grade 5 > Grade 4.
2. Maps 3-4 > Maps 1-2.

Table 14

Analysis of Variance for H-4, Controlled for Grade Level and Sex of Subjects (Maps 1 and 2 vs. Maps 3 and 4)

Source	df	Sum of Squares	Mean Squares	F-Ratios
Between Subjects	89	2108.9 +	23.696	
Sex (B)	1	1.092	1.092	.05
Grade Level (C)	2	317.214	158.607	7.46**[1]
B X C	2	3.475	1.737	.08
Between Ss Error	84	1787.133	21.275	
Within Subjects	90	470.000	5.222	
Map (A)	1	49.092	49.092	10.29**[2]
A X B	1	9.797	9.797	2.05
A X C	2	9.075	4.537	.95
A X B X C	2	1.303	.651	.14
Within Ss Error	84	400.733	4.771	
Total	179	2578.914	14.407	

**Significant at the .01 level.

1. Grade 6 > Grade 5 > Grade 4.
2. Maps 3-4 > Maps 1-2.

Table 15

Analysis of Variance for H-4, Controlled for Grade Level and I.Q. of Subjects (Maps 1 and 2 vs. Maps 3 and 4)

Source	df	Sum of Squares	Mean Squares	F-Ratios
Between Subjects	44	1053.602	23.945	
I.Q. (B)	2	232.868	116.434	9.73
Grade Level (C)	2	290.068	145.034	12.12
B X C	4	99.865	24.966	2.09
Between Ss Error	36	430.800	11.967	
Within Subjects	45	142.000	3.156	
Map (A)	1	5.379	5.379	2.01
A X B	2	.687	.344	.13
A X C	2	4.821	2.410	.90
A X B X C	4	34.713	8.678	3.24*
Within Ss Error	36	96.400	2.678	
Total	89	1195.602	13.434	

*Significant at the .05 level.

Table 16

Analysis of Variance for H-4, Controlled for Grade Level and Iowa Map Test Scores of Subjects (Maps 1 and 2 vs. Maps 3 and 4)

Source	df	Sum of Squares	Mean Squares	F-Ratios
Between Subjects	47	1074.656	22.865	
Iowa Map Test (B)	3	271.031	90.344	5.65
Grade Level (C)	2	193.000	96.500	6.03
B X C	6	34.500	5.750	.36
Between Ss Error	36	576.125	16.003	
Within Subjects	48	242.500	5.052	
Map (A)	1	36.260	36.260	14.17
A X B	3	49.615	16.538	6.46
A X C	2	6.333	3.167	1.24
A X B X C	6	58.167	9.694	3.79**
Within Ss Error	36	92.125	2.559	
Total	95	1317.156	13.865	

**Significant at the .01 level.

Table 17

Analysis of Variance for H-5, Controlled for Grade Level and SES of Subjects (Maps 1 and 3 vs. Maps 2 and 4)

Source	df	Sum of Squares	Mean Squares	F-Ratios
Between Subjects	95	1101.746	11.597	
SES (B)	1	53.132	53.132	5.72*[1]
Grade Level (C)	2	195.074	97.537	10.51**[2]
B X C	2	18.259	9.130	.98
Between Ss Error	90	835.281	9.281	
Within Subjects	96	378.500	3.943	
Map (A)	1	73.757	73.757	24.04**[3]
A X B	1	.421	.421	.14
A X C	2	10.697	5.348	1.74
A X B X C	2	17.470	8.735	2.85
Within Ss Error	90	276.156	3.068	
Total	191	1480.246	7.750	

*Significant at the .05 level.
**Significant at the .01 level.

1. High SES > Low SES.
2. Grade 6 > Grade 5 > Grade 4.
3. Maps 2-4 > Maps 1-3.

Table 18

Analysis of Variance for H-5, Controlled for Grade Level and Sex of Subjects (Maps 1 and 3 vs. Maps 2 and 4)

Source	df	Sum of Squares	Mean Squares	F-Ratios
Between Subjects	89	1051.645	11.816	
Sex (B)	1	41.089	41.089	4.27*[1]
Grade Level (C)	2	194.711	97.356	10.11**[2]
B X C	2	7.244	3.622	.38
Between Ss Error	84	808.600	9.626	
Within Subjects	90	360.000	4.000	
Map (A)	1	74.756	74.756	23.66**[3]
A X B	1	1.089	1.089	.34
A X C	2	9.911	4.956	1.57
A X B X C	2	8.845	4.422	1.40
Within Ss Error	84	265.400	3.160	
Total	179	1411.645	7.886	

*Significant at the .05 level.
**Significant at the .01 level.

1. Males > Females.
2. Grade 6 > Grade 5 > Grade 4.
3. Maps 2-4 > Maps 1-3.

Table 19

Analysis of Variance for H-5, Controlled for Grade Level and I.Q. of Subjects (Maps 1 and 3 vs. Maps 2 and 4)

Source	df	Sum of Squares	Mean Squares	F-Ratios
Between Subjects	44	564.289	12.825	
I.Q. (B)	2	99.756	49.878	5.75**[1]
Grade Level (C)	2	134.022	67.011	7.73**[2]
B X C	4	18.311	4.578	.53
Between Ss Error	36	312.200	8.672	
Within Subjects	45	161.500	3.589	
Map (A)	1	15.211	15.211	4.85*[3]
A X B	2	2.822	1.411	.45
A X C	2	10.155	5.078	1.62
A X B X C	4	20.311	5.078	1.62
Within Ss Error	36	113.000	3.139	
Total	89	725.789	8.155	

*Significant at the .05 level.
**Significant at the .01 level.

1. High, Average I.Q. > Low I.Q.
2. Grades 6,5 > Grade 4.
3. Maps 2-4 > Maps 1-3.

Table 20

Analysis of Variance for H-5, Controlled for Grade Level and Iowa Map Test Scores of Subjects (Maps 1 and 3 vs. Maps 2 and 4)

Source	df	Sum of Squares	Mean Squares	F-Ratios
Between Subjects	47	601.833	12.805	
Iowa Map Test (B)	3	161.250	53.750	7.28**[1]
Grade Level (C)	2	125.896	62.948	8.53**[2]
B X C	6	48.937	8.156	1.10
Between Ss Error	36	265.750	7.382	
Within Subjects	48	184.000	3.833	
Map (A)	1	40.042	40.042	13.76**[3]
A X B	3	8.708	2.903	1.00
A X C	2	4.021	2.010	.69
A X B X C	6	26.479	4.413	1.52
Within Ss Error	36	104.750	2.910	
Total	95	785.833	8.272	

**Significant at the .01 level.

1. Iowa upper 1/2 > Iowa lower 1/2.
2. Grade 6 > Grades 5,4.
3. Maps 2-4 > Maps 1-3.

Table 21

Analysis of Variance for H-6, Controlled for Grade Level and SES of Subjects (Maps 1 and 2 vs. Map 4)

Source	df	Sum of Squares	Mean Squares	F-Ratios
Between Subjects	95	1226.813	12.914	
SES (B)	1	65.333	65.333	6.66*[1]
Grade Level (C)	2	275.375	137.688	14.04**[2]
B X C	2	3.792	1.896	.19
Between Ss Error	90	882.313	9.803	
Within Subjects	96	375.000	3.906	
Map (A)	1	4.688	4.688	1.16
A X B	1	1.333	1.333	.33
A X C	2	5.375	2.688	.67
A X B X C	2	.542	.271	.07
Within Ss Error	90	363.063	4.034	
Total	191	1601.813	8.386	

*Significant at the .05 level.
**Significant at the .01 level.

1. High SES > Low SES.
2. Grades 6,5 > Grade 4.

Table 22

Analysis of Variance for H-6, Controlled for Grade Level and Sex of Subjects (Maps 1 and 2 vs. Map 4)

Source	df	Sum of Squares	Mean Squares	F-Ratios
Between Subjects	89	1195.801	13.436	
Sex (B)	1	8.023	8.023	.73
Grade Level (C)	2	261.734	130.867	11.96**[1]
B X C	2	7.244	3.622	.33
Between Ss Error	84	918.800	10.938	
Within Subjects	90	348.000	3.867	
Map (A)	1	3.756	3.756	.98
A X B	1	8.021	8.021	2.09
A X C	2	2.977	1.488	.39
A X B X C	2	10.712	5.356	1.39
Within Ss Error	84	322.533	3.840	
Total	179	1543.801	8.625	

**Significant at the .01 level.

1. Grades 6,5 > Grade 4.

Table 23

Analysis of Variance for H-6, Controlled for Grade Level and I.Q. of Subjects (Maps 1 and 2 vs. Map 4)

Source	df	Sum of Squares	Mean Squares	F-Ratios
Between Subjects	44	517.402	11.759	
I.Q. (B)	2	111.269	55.635	8.17**[1]
Grade Level (C)	2	148.069	74.035	10.87**[2]
B X C	4	12.864	3.216	.47
Between Ss Error	36	245.200	6.811	
Within Subjects	45	173.500	3.856	
Map (A)	1	6.947	6.947	1.81
A X B	2	3.620	1.810	.47
A X C	2	2.020	1.010	.26
A X B X C	4	22.913	5.728	1.49
Within Ss Error	36	138.000	3.833	
Total	89	690.902	7.763	

**Significant at the .01 level.

1. High, Average I.Q. > Low I.Q.
2. Grade 6 > Grade 5 > Grade 4.

Table 24

Analysis of Variance for H-6, Controlled for Grade Level and Iowa Map Test Scores of Subjects (Maps 1 and 2 vs. Map 4)

Source	df	Sum of Squares	Mean Squares	F-Ratios
Between Subjects	47	435.961	9.276	
Iowa Map Test (B)	3	139.044	46.348	10.41**[1]
Grade Level (C)	2	76.898	38.449	8.64**[2]
B X C	6	59.768	9.961	2.24
Between Ss Error	36	160.250	4.451	
Within Subjects	48	157.000	3.271	
Map (A)	1	.044	.044	.01
A X B	3	8.706	2.902	.80
A X C	2	1.893	.947	.26
A X B X C	6	16.107	2.684	.74
Within Ss Error	36	130.250	3.618	
Total	95	592.961	6.242	

**Significant at the .01 level.

1. Iowa upper 1/2 > next 1/4 > Iowa lower 1/4.
2. Grade 6 > Grade 5 > Grade 4.

Table 25

Analysis of Variance for H-7, Controlled for Grade Level and SES of Subjects (Map 1 vs. Map 2)

Source	df	Sum of Squares	Mean Squares	F-Ratios
Between Subjects	95	267.667	2.818	
SES (B)	1	2.521	2.521	1.02
Grade Level (C)	2	36.385	18.193	7.33**[1]
B X C	2	5.323	2.661	1.07
Between Ss Error	90	223.438	2.483	
Within Subjects	96	105.000	1.094	
Map (A)	1	1.688	1.688	1.54
A X B	1	.750	.750	.68
A X C	2	2.344	1.172	1.07
A X B X C	2	1.531	.766	.70
Within Ss Error	90	98.688	1.097	
Total	191	372.667	1.951	

**Significant at the .01 level.

1. Grades 6,5 > Grade 4.

Table 26

Analysis of Variance for H-7, Controlled for Grade Level and Sex of Subjects (Map 1 vs. Map 2)

Source	df	Sum of Squares	Mean Squares	F-Ratios
Between Subjects	89	261.200	2.935	
Sex (B)	1	3.756	3.756	1.47
Grade Level (C)	2	42.034	21.017	8.20**[1]
B X C	2	.078	.039	.02
Between Ss Error	84	215.333	2.563	
Within Subjects	90	99.000	1.100	
Map (A)	1	2.222	2.222	1.99
A X B	1	.800	.800	.72
A X C	2	1.811	.905	.81
A X B X C	2	.300	.150	.13
With Ss Error	84	93.867	1.117	
Total	179	360.200	2.012	

**Significant at the .01 level.

1. Grades 6,5 > Grade 4.

Table 27

Analysis of Variance for H-7, Controlled for Grade Level and I.Q. of Subjects (Map 1 vs. Map 2)

Source	df	Sum of Squares	Mean Squares	F-Ratios
Between Subjects	44	139.289	3.166	
I.Q. (B)	2	19.622	9.811	4.83*[1]
Grade Level (C)	2	36.956	18.478	9.09**[2]
B X C	4	9.511	2.378	1.17
Between Ss Error	36	73.200	2.033	
Within Subjects	45	32.000	.711	
Map (A)	1	.711	.711	1.05
A X B	2	2.022	1.011	1.49
A X C	2	.555	.278	.41
A X B X C	4	4.311	1.078	1.59
Within Ss Error	36	24.400	.678	
Total	89	171.289	1.925	

*Significant at the .05 level.
**Significant at the .01 level.

1. High, Average I.Q. > Low I.Q.
2. Grades 6,5 > Grade 4.

Table 28

Analysis of Variance for H-7, Controlled for Grade Level and Iowa Map Test Scores of Subjects (Map 1 vs. Map 2)

Source	df	Sum of Squares	Mean Squares	F-Ratios
Between Subjects	47	146.625	3.120	
Iowa Map Test (B)	3	37.458	12.486	5.60**[1]
Grade Level (C)	2	21.938	10.969	4.92*[2]
B X C	6	6.979	1.163	.52
Between Ss Error	36	80.250	2.229	
Within Subjects	48	44.000	.917	
Map (A)	1	4.167	4.167	4.44*[3]
A X B	3	1.667	.556	.59
A X C	2	.396	.198	.21
A X B X C	6	4.021	.670	.71
Within Ss Error	36	33.750	.938	
Total	95	190.625	2.007	

*Significant at .05 level.
**Significant at .01 level.

1. Iowa upper 1/4 > next 1/2 > Iowa lowest 1/4.
2. Grade 6 > Grades 5,4.
3. Map 2 > Map 1.

Table 29

Orthogonal Comparison Summary Table for H-8, Based on Means and Within Error Terms from Analyses of Variance over SES, Sex, I.Q., and Iowa Test Scores of Subjects--Each over Grade Level and Scores on Appropriate Items of Maps 1, 2, 3, and 4

Status Variable	N	Mean Squares	Within Error Term	F-Ratio	P(F)
SES	96	1.83	3.15	.58	.55
Sex	90	1.01	3.14	.32	.58
I.Q.	45	.66	.99	.25	.63
Iowa	48	2.01	3.06	.66	.57

Table 30

Orthogonal Comparison Summary Table for H-9, Based on Means and Within Error Terms from Analyses of Variance over SES, Sex, I.Q., and Iowa Test Scores of Subjects--Each over Grade Level and Scores on Appropriate Items of Maps 1, 2, 3, and 4

Status Variable	N	Mean Squares	Within Error Term	F-Ratio	P(F)
SES	96	.17	3.15	.05	.81
Sex	90	2.41	3.14	.77	.61
I.Q.	45	.81	.99	.30	.59
Iowa	48	8.51	3.06	2.77	.09

Table 31

Analysis of Variance for H-10, Controlled for Grade Level and SES of Subjects (Maps 2 and 4 vs. Maps 1 and 3)

Source	df	Sum of Squares	Mean Squares	F-Ratios
Between Subjects	95	6461.500	68.016	
SES (B)	1	320.354	320.354	6.39*[1]
Grade Level (C)	2	1610.531	805.266	16.05**[2]
B X C	2	15.802	7.901	.16
Between Ss Error	90	4514.813	50.165	
Within Subjects	96	1199.000	12.490	
Map (BA)	1	117.208	117.208	10.18**[2]
A X B	1	18.729	18.729	1.63
A X C	2	23.823	11.911	1.03
A X B X C	2	2.552	1.276	.11
Within Ss Error	90	1036.688	11.591	
Total	191	7660.500	40.107	

*Significant at the .05 level.
**Significant at the .01 level.

1. High SES > Low SES.
2. Grades 6,5 > Grade 4.
3. Maps 2-4 > Maps 1-3.

Table 32

Analysis of Variance for H-10, Controlled for Grade Level and Sex of Subjects (Maps 2 and 4 vs. Maps 1 and 3)

Source	df	Sum of Squares	Mean Squares	F-Ratios
Between Subjects	89	6359.313	71.453	
Sex (B)	1	62.424	62.424	1.10
Grade Level (C)	2	1523.146	761.573	13.47**[1]
B X C	2	24.410	12.205	.22
Between Ss Error	84	4749.333	56.540	
Within Subjects	90	1101.000	12.233	
Map (A)	1	80.001	80.001	6.83*[2]
A X B	1	3.754	3.754	.32
A X C	2	29.099	14.549	1.24
A X B X C	2	3.746	1.873	.16
Within Ss Error	84	984.400	11.719	
Total	179	7460.313	41.678	

*Significant at the .05 level.
**Significant at the .01 level.

1. Grades 6,5 > Grade 4.
2. Maps 2-4 > Maps 1-3.

Table 33

Analysis of Variance for H-10, Controlled for Grade Level and I.Q. of Subjects (Maps 2 and 4 vs. Maps 1 and 3)

Source	df	Sum of Squares	Mean Squares	F-Ratios
Between Subjects	44	2966.289	67.416	
I.Q. (B)	2	927.022	463.511	16.85**[1]
Grade Level (C)	2	928.622	464.311	16.88**[2]
B X C	4	120.444	30.111	1.09
Between Ss Error	36	990.200	27.506	
Within Subjects	45	501.000	11.133	
Map (A)	1	40.000	40.000	3.79
A X B	2	19.466	9.733	.92
A X C	2	5.600	2.800	.27
A X B X C	4	56.134	14.033	1.33
Within Ss Error	36	379.800	10.550	
Total	89	3467.289	38.958	

**Significant at .01 level.

1. High, Average I.Q. > Low I.Q.
2. Grade 6 > Grade 5 > Grade 4.

Table 34

Analysis of Variance for H-10, Controlled for Grade Level and Iowa Map Test Scores of Subjects (Maps 2 and 4 vs. Maps 1 and 3)

Source	df	Sum of Squares	Mean Squares	F-Ratios
Between Subjects	47	3127.625	66.545	
Iowa Map Test (B)	3	1376.708	458.903	17.55**[1]
Grade Level (C)	2	600.063	300.031	11.48**[2]
B X C	6	209.604	34.934	1.34
Between Ss Error	36	941.250	26.146	
Within Subjects	48	489.000	10.188	
Map (A)	1	92.042	92.042	9.75**[3]
A X B	3	36.208	12.069	1.28
A X C	2	8.521	4.260	.45
A X B X C	6	12.479	2.080	.22
Within Ss Error	36	339.750	9.438	
Total	95	3616.625	38.070	

**Significant at the .01 level.

1. Iowa upper 1/4 > next 1/4 > next 1/4 > Iowa lower 1/4.
2. Grade 6 > Grade 5 > Grade 4.
3. Maps 2-4 > Maps 1-3.

Table 35

Analysis of Variance for H-11A, Total Scores on Three Physical-Political Maps, Controlled for Grade Level and SES of Subjects (Maps 1, 2, and 4)

Source	df	Sum of Squares	Mean Squares	F-Ratios
Between Subjects	95	17535.167	184.581	
SES (B)	1	1229.285	1229.285	10.30**[1]
Grade Level (C)	2	5486.365	2743.182	22.99**[2]
B X C	2	79.163	39.582	.33
Between Ss Error	90	10740.354	119.337	
Within Subjects	192	3275.333	17.059	
Map (A)	2	270.302	135.151	8.48**[3]
A X B	2	53.392	26.696	1.68
A X C	4	17.302	4.326	.27
A X B X C	4	66.503	16.626	1.04
Within Ss Error	180	2867.833	15.931	
Total	287	20810.500	72.510	

**Significant at the .01 level.

1. High SES > Low SES.
2. Grades 6,5 > Grade 4.
3. Maps 2,4 > Map 1.

Table 36

Analysis of Variance for H-11A, Total Scores on Three Physical-Political Maps, Controlled for Grade Level and Sex of Subjects (Maps 1, 2, and 4)

Source	df	Sum of Squares	Mean Squares	F-Ratios
Between Subjects	89	17376.854	195.246	
Sex (B)	1	372.217	372.217	2.73
Grade Level (C)	2	5443.599	2721.799	19.96**[1]
B X C	2	103.883	51.941	.38
Between Ss Error	84	11457.156	136.395	
Within Subjects	180	3051.333	16.952	
Map (A)	2	233.599	116.799	7.13**[2]
A X B	2	14.283	7.141	.44
A X C	4	17.424	4.356	.27
A X B X C	4	33.984	8.496	.52
Within Ss Error	168	2752.044	16.381	
Total	269	20428.188	75.941	

**Significant at the .01 level.

1. Grades 6,5 > Grade 4.
2. Maps 2,4 > Map 1.

Table 37

Analysis of Variance for H-11A, Total Scores on Three Physical-Political Maps, Controlled for Grade Level and I.Q. of Subjects (Maps 1, 2, and 4)

Source	df	Sum of Squares	Mean Squares	F-Ratios
Between Subjects	44	8385.479	190.579	
I.Q. (B)	2	2564.012	1282.006	18.87
Grade Level (C)	2	3016.146	1508.073	22.20
B X C	4	359.854	89.964	1.32
Between Ss Error	36	2445.467	67.930	
Within Subjects	90	1323.333	14.704	
Map (A)	2	94.901	47.451	4.30
A X B	4	48.565	12.141	1.10
A X C	4	39.365	9.841	.89
A X B X C	8	346.368	43.296	3.93**
Within Ss Error	72	794.133	11.030	
Total	134	9708.813	72.454	

**Significant at the .01 level.

Table 38

Analysis of Variance for H-11A, Total Scores on Three Physical-Political Maps, Controlled for Grade Level and Iowa Map Test Scores of Subjects (Maps 1, 2, and 4)

Source	df	Sum of Squares	Mean Squares	F-Ratios
Between Subjects	47	8131.000	173.000	
Iowa Map Test (B)	3	3502.611	1167.537	17.48**[1]
Grade Level (C)	2	1824.042	912.021	13.66**[2]
B X C	6	400.014	66.669	1.00
Between Ss Error	36	2404.333	66.787	
Within Subjects	96	1514.000	15.771	
Map (A)	2	130.792	65.396	4.69*[3]
A X B	6	74.097	12.350	.89
A X C	4	26.292	6.573	.47
A X B X C	12	279.653	23.304	1.67
Within Ss Error	72	1003.167	13.933	
Total	143	9645.000	67.448	

*Significant at the .05 level.
**Significant at the .01 level.

1. Iowa upper 1/2 > next 1/4 > Iowa Lower 1/4.
2. Grade 6 > Grade 5 > Grade 4.
3. Maps 2,4 > Map 1.

Table 39

Analysis of Variance for H-11B, Total Scores on All Four Maps with Elevation/Water Depth Sub-test Omitted, Controlled by Grade Level and SES of Subjects (Maps 1, 2, 3 and 4)

Source	df	Sum of Squares	Mean Squares	F-Ratios
Between Subjects	95	14913.000	156.979	
SES (B)	1	834.260	834.260	7.73**[1]
Grade Level (C)	2	4328.734	2164.367	20.05**[2]
B X C	2	32.411	16.206	.15
Between Ss Error	90	9717.594	107.973	
Within Subjects	288	4137.500	14.366	
Map (A)	3	336.312	112.104	8.46**[3]
A X B	3	58.552	19.517	1.47
A X C	6	105.828	17.638	1.33
A X B X C	6	59.276	9.879	.75
Within Ss Error	270	3577.531	13.250	
Total	383	19050.500	49.740	

**Significant at the .01 level.

1. High SES > Low SES.
2. Grades 6,5 > Grade 4.
3. Maps 2,4 > Map 3; Map 2 > Map 1.

Table 40

Analysis of Variance for H-11B, Total Scores on All Four Maps with Elevation/Water Depth Sub-test Omitted, Controlled by Grade Level and Sex of Subjects (Maps 1, 2, 3 and 4)

Source	df	Sum of Squares	Mean Squares	F-Ratios
Between Subjects	89	14765.063	165.900	
Sex (B)	1	342.274	342.274	2.84
Grade Level (C)	2	4228.121	2114.060	17.51**[1]
B X C	2	53.268	26.634	.22
Between Ss Error	84	10141.400	120.731	
Within Subjects	270	3891.250	14.412	
Map (A)	3	279.035	93.012	6.82**[2]
A X B	3	26.649	8.883	.65
A X C	6	129.724	21.621	1.59
A X B X C	6	19.643	3.274	.24
Within Ss Error	252	3436.200	13.636	
Total	359	18656.313	51.967	

**Significant at the .01 level.

1. Grades 6,5 > Grade 4.
2. Map 2 > Maps 1,3.

Table 41

Analysis of Variance for H-11B, Total Scores on All Four Maps with Elevation/Water Depth Sub-test Omitted, Controlled by Grade Level and I.Q. of Subjects (Maps 1, 2, 3, and 4)

Source	df	Sum of Squares	Mean Squares	F-Ratios
Between Subjects	44	7321.750	166.403	
I.Q. (B)	2	2194.583	1097.292	18.29
Grade Level (C)	2	2645.683	1322.842	22.04
B X C	4	321.183	80.296	1.34
Between Ss Error	36	2160.300	60.008	
Within Subjects	135	1819.500	13.478	
Map (A)	3	88.406	29.469	2.37
A X B	6	31.461	5.244	.42
A X C	6	57.428	9.571	.77
A X B X C	12	302.106	25.175	2.03*
Within Ss Error	108	1340.100	12.408	
Total	179	9141.250	51.068	

*Significant at the .05 level.

Table 42

Analysis of Variance for H-11B, Total Scores on All Four Maps with Elevation/Water Depth Sub-test Omitted, Controlled by Grade Level and Iowa Map Test Scores of Subjects (Maps 1, 2, 3, and 4)

Source	df	Sum of Squares	Mean Squares	F-Ratios
Between Subjects	47	7131.000	151.723	
Iowa Map Test (B)	3	3192.958	1064.319	19.03**[1]
Grade Level (C)	2	1656.125	828.063	14.81**[2]
B X C	6	268.792	44.799	.80
Between Ss Error	36	2013.125	55.920	
Within Subjects	144	1857.000	12.896	
Map (A)	3	145.958	48.653	4.22**[3]
A X B	9	124.083	13.787	1.20
A X C	6	29.417	4.903	.43
A X B X C	18	313.667	17.426	1.51
Within Ss Error	108	1243.875	11.517	
Total	191	8988.000	47.058	

**Significant at the .01 level.

1. Iowa upper 1/2 > next 1/4 > Iowa lower 1/4.
2. Grade 6 > Grade 5 > Grade 4.
3. Maps 2,4 > Map 3.